# *To what extent do financing constraints, herding behavior and ownership affect firms' innovation activities? Evidence from China*


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# To what extent do financing constraints, herding behavior and ownership affect firms' innovation activities? Evidence from China


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# Abstract

Maintaining high economic growth rate is arguable the central challenge for China's macroeconomic policy in the coming decade. The development of innovation, especially in business sectors, is critical for China to meet that challenge. Therefore, it is important to understand the innovation activities in Chinese enterprises. However, due to high adjustment costs and the high uncertainty of innovation activities, innovative firms generally suffer more from asymmetric information than their counterparts who do not engage in innovation activities, which cause lending bias and herding behavior in the market. In addition, because of "political pecking order" in China, firm with different ownership (state-owned, foreign-owned, private-owned, and collective-owned) will behave differently and their ownership level will also directly and indirectly affect firms' innovation activities.

This thesis, using the firm-level data from the NBS (National Bureau of Statistics of China) over the period 2000−2007, investigates the effects of financial constraints, herding behavior, and various ownerships on firms' innovation activities form both macroeconomics and microeconomics perspectives.

Specifically, the first empirical chapter of this thesis investigates the extent to which financing constraints affect the innovation activities. Based on a variety of specifications and estimation methods, we document that Chinese firms' innovation activities are constrained by the availability of internal finance. Specifically, private firms suffer the most, followed by foreign firms, while state-owned and collective enterprises are the least constrained. Moreover, the availability of internal finance represents a particularly binding constraint on the innovation activities of small firms, located in the coastal provinces, with low political affiliation, and fewer state shares, as well as for sole proprietorship firms.

Next, Chapter Four investigates the extent to which Chinese firms display herding behavior in their innovation activities, and then assess the impact of this behavior on corporate productivity. Based on a variety of different specifications, we find strong evidence in favor of herding in Chinese firms' innovation activities. In particular, private, small firms, with no political affiliation are more likely to herd. We also find that innovation herding has a negative effect on productivity.

The final empirical chapter of this thesis investigates the extent to which state and foreign ownership affect firms' innovation activities. We firstly find a significant positive effect of joint ventures on innovation activity. Moreover, our results display an inverse U-shaped relationship between state ownership and product innovation. Foreign-affiliated firms, especially foreign-affiliated joint-venture firms, are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases. We also report strong evidence that, conditional on absorptive capacity, the relationship between foreign ownership and product innovation becomes positive for foreign-affiliated joint-venture firms.

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# List of Abbreviations

| | |
|---|---|
| FDI | foreign direct investment |
| GDP | gross domestic product |
| IPR | intellectual property rights |
| IT | information technology |
| JV | joint venture |
| LMEs | large and medium-sized enterprises |
| MOST | Ministry of Science and Technology |
| NBS | National Bureau of Statistics |
| OECD | Organisation for Economic Co-operation and Development |
| PA | political affiliation |
| PROD | productivity |
| R&D | research and development |
| SMEs | small and medium-sized enterprises |
| SOE | state-owned enterprises |
| SP | sole proprietorships |
| TFP | total factor productivity |
| VAPW | value add per worker |
| VC | venture capital |

# Declaration

The material contained in the thesis has not previously been submitted, either in whole or in part, for a degree in this or any other institution.

# Statement of Copyright

# Acknowledgements

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A huge thank you goes to my parents, Shuyong Liu and Shuanglan Jin. Whatever I have achieved and whatever I will achieve in the future is as a direct result of your continued love and support. Words cannot express how much you all mean to me and I will forever be thankful that it is you who are my family.

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***To my beloved parents***

# Chapter 1

# Introduction

## 1.1. Introduction

China has achieved remarkable economic success over the last several decades due to its reforming and opening-up policy since 1978. Its GDP (gross domestic product) has grown by an average of 9 percent a year for the past 20 years, which lifted more than 600 million people out of poverty. Can this economic growth rate and poverty reduction speed, as well as the social and environmental progress, be maintained and comprehended? This is the central challenge that China has faced historically, and still faces today. The development of innovation, especially in business enterprises, plays a major role for China to meet that challenge. As proposed by a large number of literature, innovation has been generally viewed as a central element of endogenous growth models, and has been widely considered as a key driver of economic growth (Romer, 1990; Aghion and Howitt, 1992).

The Chinese government has always attached great importance to the positive role of innovation on economic performance, and has made a range of policy to promote innovation. In recent years, with China's rapid economic growth, the

Chinese government has been showing even greater interest in innovation. In 2006, after several years of intensive investigation and consultation, the government officially released "The Medium- and Long-term Strategic Plan for the Development of Science and Technology (2006–2020)" (the 2006 S&T program) and "The Decision on Implementing the Medium- and Long-term Strategic Plan for the Development of Science and Technology and Improving Indigenous Innovation Capability" (the Decision), which aimed at strengthening China's scientific and technological (S&T) progress, and achieve an innovation-oriented society by 2020. The guidelines are expressed in 16 Chinese characters: indigenous innovation (*zizhu chuangxin*), leapfrogging in key areas (*zhongdian kuayue*), S&T supporting economic and social development (*zhicheng fazhan*), and S&T leading the future (*yinling weilai*). The first pillar, indigenous innovation, is the central theme of the new policy, which codifies the determination to reduce China's dependence on foreign technology. Specifically, it refers to enhancing original innovation, integrated innovation, and re-innovation based on assimilation and absorption of imported technology. The notion of indigenous innovation is complemented in the 2006 S&T program by a greater emphasis on the role of business enterprises in technological innovation. Both the 2006 S&T program and the Decision called for a "leading role" for enterprises in technological innovation. In stating the guiding principles of S&T system reform, the 2006 S&T program identifies "a technological innovation system led by enterprises" as the "point of breakthrough". The Decision elaborates on how indigenous innovation is to be achieved:

> *"The key to increasing indigenous innovation capacity is to strengthen the leading role of enterprises in technological innovation to build up a technological innovation system that is led by enterprises, guided by the*

*market, and characterized by collaboration of industries, HEIs and research institutes. More effective measures must be taken to create a more conductive environment that enables enterprises to play a leading role in R&D expenditure technological innovation activities as well as the application of results of innovation. ”*

These policies demonstrate the importance in understanding the role of enterprises in conducting technological innovation, and motivate us to investigate China’s innovation activities at the firm level. As Chinese enterprises generally characterized as varying ownership types (state-owned, foreign-owned, private-owned, and collective-owned), different ownership structures (joint ventures, and fully owned), and distributed in diverse regions (eastern/coastal region, central region, and western region), it is therefore interesting to consider the importance of firm heterogeneity in innovation actives. And China provides us an ideal laboratory to conduct this research.

## 1.2. The motivation of this study

Although having made great economic progress in recent years, the biggest challenge for China to develop innovation is its underdeveloped market and the laggard financial system. Especially, the government continues to play an influential role in the allocation of key resources, which may cause distortion in the market. As proposed by Modigliani and Miller (1958), in a perfect capital market, firm’s investment activities should be irrelevant to its financing decisions. However, a large number of factors, such as taxes, transaction costs, and most importantly information asymmetries, can lead to imperfections in the capital market. A pioneered framework conducted by Fazzari et al. (1988) tests for the financial constraints by looking at the sensitivity of cash flow to investment. Their results show that internal finance is an important determinant of US firms' fixed investment. Subsequently, a branch of literature has adapted this approach to examine the impact of financial constraints on fixed investment in other countries (Hoshi et al., 1991; Hubbard et al., 1995; Konings et al., 2003; Poncet et al. 2010). The other branch of literature has extended the study beyond fixed investment to analyze the impact of financial constraints on other on other firms' activities, such as innovation investment (Hall, 1992; Brown and Petersen et al., 2009; Brown et al., 2009). However, very few studies have attempted to focus this on China, which motivate us to investigate the extent to which financing constraints affect the innovation activities in the context of Chinese firms, as well as to explore firms' heterogeneity.

In addition, innovation should be a firm-level idiosyncratic activity in a perfect market. Firms should make innovation decisions individually by considering their financial capacity (e.g. the amount of free cash flow available to them), assessing their willingness to undertake risky activities, and taking into account the value of and social demand for new products. However, due to high adjustment costs and the high uncertainty of innovation activities (Hall, 1992; Hall and Lerner, 2010), innovative firms generally suffer more from asymmetric information than their counterparts who do not engage in innovation activities. It is therefore often difficult for the managers of innovative firms to assess the value of potential new projects. In other words, private information on specific innovation projects is limited. Yet, it is reasonable to believe that managers are aware of the average innovation investment made by other firms in the same industry, which can be viewed as public information. Given that private information is limited, one strategy for managers is to mimic the behavior of their peers, based on public information. Because of the underdeveloped market in China, it is interesting to test whether firms' innovation activities tend to some degree to "move with the market" or "follow the general market trend".

Moreover, China's reforms have not only promoted economic development but also led to significant changes in ownership structures as represented in firms' increasingly diversified ownership forms, such as a fall in state ownership and a rise in foreign and private ownership (Jefferson and Singh, 1998). These changes may affect firms' innovation through issues of corporate governance, managerial discretion, resource allocation, risk distribution, and international cooperation (Li et al., 2008; Dong and Gou, 2010), which may further impact firms' activities, such as innovation investment. This motivates us to investigate firms' innovation activities across different ownership types and at different ownership levels.

## 1.3. The purpose of this study

The understanding the effects of financial constraints, herding behavior, ownership and firms' innovation activities is an important issue from both macroeconomics and microeconomics perspectives. Specifically, a good understanding of the effect of financial constraints and firms' innovation activities would provide valuable information about the mechanism through which monetary policy affect real economic activities and the understanding of macroeconomic dynamics. Moreover, herding behavior helps us to realize how market uncertainty affects investment behavior in innovation activities and what is the impact of this behavior on real economic productivity. In addition, the analysis of ownership emphasizes the importance of ownership reform on technological upgrading in a macro-market.

Furthermore, from a microeconomics perspective, the study of the effects of financial constraints, herding behavior, and ownership also contributes to the understanding of firms' corporate finance, behavior finance, corporate governance and the importance of firm heterogeneity in firms' innovation activities.

## 1.4. A broad definition of innovation

There are many definitions on innovation in literature. Narrowly, it can be explained as the creation of technology that is new to the world. Nelson and Rosenberg (1993) define innovation more broadly as "to encompass the processes by which firms master and get into practice product designs and manufacturing processes that are new to them, if not to the universe or even to the nation". In certain cases, adoption of a technology that is only "new to the firm" could appear too far from the notion of "innovation". However, on balance, when performance in economic development is the central concern, it is the broadly defined concept of innovation that matters more (Nelson and Rosenberg, 1993).

This study adopts the broad definition to cover two distinct sets of innovation activity by firms. The first set is new products from a firm perspective. According to the NBS, new products are defined as "those [products] new to the Chinese market, which either adopt completely new scientific principles, technologies, or designs or are substantially improved in comparison with existing products in terms of performance and functionality, through significant changes in structure, materials, design, or manufacturing processes" (China Statistical Yearbook, 2006). A firm's new products are subject to local governments' certification, which is generally valid for up to three years. New product sales have been widely used in recent research papers to represent firms' innovation activities. As they represent the output of firms' innovation activities, they are believed to be a more suitable measure than R&D, which is simply an input into the innovation process (Criscuolo et al., 2005; Girma, Gong and Gorg, 2008). In addition, the McKinsey survey (McKinsey & Co., 2008) suggests that product innovation is the indicator most used by companies to track innovative performance. Moreover, according to recent changes in the Chinese accounting system, R&D expenditure is only directly disclosed after 2005 (Li, Chen and Shapiro, 2010), while new product sales are available throughout our sample (with the exception of 2004). We therefore use new product sales to total assets or total sales to measure firms' innovation activities, and call this variable *product innovation*. But we will still use R&D expenditures as a robustness test, which is also the second set measure of innovation activity.

# Chapter 2

# An overview of China's innovation

## 2.1. China's national innovation system

The concept of the NIS (national innovation system) encompasses the set of political and other factors that determine a society's ability to define creatively and achieve increasingly ambitious cultural, social and economic goals. The history of China, like that of any other nation, can be analyzed from this perspective. In contemporary economic thinking, an innovation system is defined as the purposeful combination of market and non-market mechanisms to optimize the production, deployment and use of new knowledge for sustainable growth, through institutionalized processes in the public and private sector.

The evolution of China' national innovation system during the pre-reform period (1949-1978) can be divided into five stages:

- **1949−1952**: the first four-year stage was a period of reconstruction or recovery. The Chinese Academy of Sciences (CAS) and many industrial research institutes were founded during that time.

- **1953−1957**: China's first Five-Year-Plan was released in this period. This stage was characterized by massive technology transfers from the former Soviet Union, which also provide China with a model for organizing research. China's innovation system during this period could be characterized by a "compartmentalized, even fragmented" approach, whereby institutes such as the CAS were designated to undertake research while universities were devoted to education. Meanwhile, technological R&D activities were separated from industries. A major event of this second stage was the drafting of China's first long-range S&T program "The 12-year Plan for Scientific and Technological Development (1956-1967)", which included 12 major industrial fields of technology, such as atomic energy, radio electronics, transistors, automation, computing techniques, aeronautics, and optics and precision instruments. In addition, the program specified 57 major tasks for basic research. The plan's objectives were completed by 1962, five years ahead of schedule, despite interruptions caused by the Great Leap Forward (1958–1960).
- **1958−1960**: during the Great Leap Forward, constituting the third stage, China's leadership attempted to break away from the influence of the Soviet model, which emphasized the development of heavy industry and large enterprises. The leadership attempted to accelerate growth in both agriculture and industry, and in both large and small enterprises, using moderns as well as indigenous methods. In reforming its S&T system, the Chinese government encouraged research activities as the provincial and sub-provincial levels. It also emphasized the relevance of research to economic production, in order to strengthen the link between the two. However,

because of its unrealistic goals and strategies, the Great Leap Forward failed, the S&T activities were badly disrupted.

- **1961−1965**: the fourth stage was characterized by adjustment and recovery form economic recession in the early 1960s after the Sino-Soviet rift, and the subsequent withdrawal of Soviet technical advisors, China accelerated its indigenous S&T efforts, particularly in military-related fields. The Chinese leadership returned to some of the approaches used in its first Five-Year-Plan, while emphasizing the applicability of scientific research. During this period, China also drafted its second S&T program (1963–1972), which included 374 major projects, 333 of which could be characterized as applied industrial technologies. The program emphasized self-reliance and indigenous efforts in developing technologies, which was related to China's separation from the former Soviet Union. Meanwhile, the program also stated that "science and technology is the key to modernizing agriculture, industry, national security, and science and technology (Four Modernizations)".
- **1966−1977**: the fifth and final pre-reform stage was among the most chaotic periods (the Cultural Revolution) in the history of the People's Republic of China. Except in military-related fields, R&D activities were seriously disrupted. Many intellectuals were denounced as "stinking number nine" (or the group with the lowest social status in the nine classes) and tortured physically and mentally. A number of scientific research institutions were eliminated or downsized, and various groups of S&T personnel were disbanded. In 1965, a year before the Cultural Revolution, the CAS administered 106 governmental laboratories employing 22,000 scientists and engineers. In contrast, in 1973 the number of government laboratories and

scientists under the CAS had fallen to 53 and 13,000 respectively. An authoritative source on the history of China's science reported that all major S&T accomplishments during this period were related to national defence − for example, atomic and hydrogen bombs, missiles, and satellites.

To summarize, the government was the driving force of innovation as well as economic performance during China's pre-reform era, which clearly separate from industrial enterprises and universities. The development of military technologies was China's priority in that period, while innovation in civilian industries were largely ignored and poorly managed. These problems set the stage for reforms in the decades that followed. The evolution of China' national innovation system after reform can be divided into five stages:

- **1978−1984**: the period can be seeing as a spontaneous trial stage. At the National Science Conference in March 1978, Deng Xiaoping made a series of speeches articulating the idea that "science and technology are a productive force" in an effort to initiate restoration of S&T infrastructure destroyed during the Cultural Revolution. During the conference, China announced it "National Plan for the Development of S&T (1978–1985)", which emphasized basic research. Soon after the conference, the R&D facilities damaged by the Cultural Revolution were rapidly revitalized. In 1978, the National S&T Commission resumed operations, and by 1979 the number of CAS-administered governmental laboratories rose to 129, while S&T personnel increased to 24,000. Scientific experts resumed leadership in governmental laboratories and the principle of excellence was restored as the basis for assignment and promotion of S&T personnel. Restoration of order was the key objective of the period 1978–1980. Soon, China's leaders realized that restoration of the former R&D system and increases of state investment in S&T, particularly in basic research, were insufficient to stimulate economic growth. Experiments in reforming the S&T system began in the early 1980s. The focus was on reorienting R&D activities from military to civilian products. In 1982, the central government explicitly stated that "economic development must rely on science and technology, and science and technology must be oriented toward economic development". Another indication that closer attention was being paid to the relationship between research and production was the integration of S&T planning into the Sixth Five-Year-Plan (1981–1985), the first such effort in China.

- **1985−1994**: the year 1985 signalled the beginning of massive S&T reforms, with the announcement of the central government's "Decision on Reforms of the Science and Technology System" – one of the most important documents guiding China's S&T reforms. The key initiative was creation of a technology market, intended to link R&D with industrial activities more efficiently. From 1985 to 1991, the focus of reforms was on merging governmental laboratories with industrial enterprises. The purpose was to let host enterprises control the R&D activities of research institutes with which they were merged. In early 1987, the State Council issued the "Stipulations for Deepening Reforms of the Science and Technology System". However, only a handful of governmental laboratories were merged with industrial enterprises, despite the preferential policies and recommendations from the central government. Frustrated by unsuccessful reforms in linking governmental laboratories with industrial enterprises, the central government elected to spin off new technology enterprises from governmental laboratories and universities – a new arrangement that quietly gained strength. In mid-1988, the central government initiated new policies, summarized in the "Torch Program", to promote such spinoffs. High-tech spinoff enterprises have become one of the most active parts of China's economy. [1] In the year 1987, China embarked upon the "863 Program" which adopted a bidding rather than consignment system. The government invited proposals from the public, and hired experts in different fields to review and select projects slated for funding. As such, competition was introduced intro the process, in sharp contrast to the previous approach, which allocated research funding according to the number of employees in the institutes. Consequently, the innovation system became increasingly fair and efficient. Reforms in the 1990s were characterized by a shift in approach from the previous emphasis on technology transfer to a focus on innovation, whereby enterprises are considered the center of industrial technological development. In 1993, the Central Committee of the Chinese Communist Party (CCP) issued the "Decision on Various Issues to Build a Socialist Market Economy". In the area of S&T policy, the Decision proposed that industrial enterprises become the primary force for technological innovation. This was the first time that Chinese government documents had specified this point.

- **1995–2005**: after the National Science and Technology Conference in 1995, the government issued the "Decision on Accelerating Scientific and Technological Development", which reemphasized the importance of strengthening linkages between R&D and economic development, and

[1] Successful examples include the Fanzhen Group of Beijing University, the Ziguang Group of Tsinghua University, and the Legend Group of CAS.

repeated the call for industrial enterprises to become the principal force for technological innovation. One strategy was to promote the merger of governmental laboratories with large industrial enterprises, which had largely failed in 1987. However, these initiatives were not immediately adopted, even after the government reinforced and refined the points in its “Decision to Further Reform the S&T System during the Ninth Five-Year Plan” in 1996. The 1997 Asian financial crises led the government to shift its focus to avoiding a crisis in China. After the crisis period had passed, government officials began to realize the importance of innovation in economic development. In 1999, the Chinese government convened the National Technological Innovation Conference and issued the “Decision on Strengthening Technological Innovation, Developing High-Tech Firms, and Realizing Commercialization of New Technologies”. The aim of this decision is to recognize the intricate relationship among reforms in the economy, education, S&T, and innovation, and finally create a national innovation system. And the central government proceeded to reduce its direct involvement in economic affairs. In a related move, 242 applied research laboratories hitherto administered by relative ministries were transferred to R&D units in existing state-owned industrial enterprises or to new state-owned technology enterprises charged with conducting R&D in addition to standard business activities. This approach differed from the previous ones in promoting innovation in non-state owned, medium and small industrial enterprises, whereas the previous efforts focused on large state-owned enterprises. In addition, numerous auxiliary programs were initiated to support the reform, such as experiments in the use of venture capital and the creation of a Technology Development Fund, as well as the creation of a stock market for high-tech enterprises, similar to the NASDAQ.

- **2006–now**: after the National Science and Technology Conference in 2006, the central government released "The Medium- and Long-term Strategic Plan for the Development of Science and Technology (2006–2020)" and "The Decision on Implementing the Medium- and Long-term Strategic Plan for the Development of Science and Technology and Improving Indigenous Innovation Capability". These two documents signified that China was adopting an innovation-driven development model. The Plan and the Decision propose guidelines for the development of S&T: the overall objective, goals and tasks; key areas and priority research issues; and policies and measures to implement them. The guidelines are expressed in 16 Chinese characters: indigenous innovation (*zizhu chuangxin*), leapfrogging in key areas (*zhongdian kuayue*), S&T supporting economic and social development (*zhicheng fazhan*), and S&T leading the future (*yinling weilai*).[2] The overall objective is to build an innovation-oriented society by 2020. Specifically, certain indicators are proposed, e.g. by 2020, the ratio of gross expenditure on R&D to GDP should reach or exceed 2.5%; S&T should contribute 60% to economic development; the degree of reliance on foreign technology should drop to 30%; and the international citations of Chinese-authored scientific publications should rank among the top five worldwide. The Plan defines 11 key research areas and 68 priority issues in these areas, 16 major special programmes, frontier technology programmes in eight key technology research areas, and 18 basic research topics. To implement the guidelines,

[2] Source: "China outlines strategic tasks for building innovation-oriented country" , People's Daily Online, http://english.people.com.cn/200601/09/eng20060109_233919.html

objectives and tasks mentioned above, the Plan proposes to implement measures relating to fiscal policy, public technology procurement, intellectual property rights (IPR) and standards, civil and military collaboration, international and domestic collaboration, and public understanding of science.

[Insert Table 2.1 here]

To summarize, a few new trends can be identified from the evolution of the reforms after 1980s. Specifically, there is a shift of innovation subject in emphasis from government to individual enterprises. In addition, there is a broadening of the early focus on large and medium-sized state-owned enterprises to encompass small and non-state enterprises.

## 2.2. The scale and achievements of China's innovation

China has dramatically scaled up its investment in R&D over the past ten years. Data recently released by the NBS on S&T activities permit a look into the structure of the innovation in more detail. In Figure 2.1, we observe that China's gross expenditure on R&D (GERD) increased sharply, with more than 1,000 billion yuan, 10 times than it's in 2000 (nearly 90 billion yuan). R&D expenditure to GDP ratio also increased consistently from 0.9% to 1.98% during this period. This growth is even more impressive considering that China's GDP has simultaneously grown by close to 9% per year on average.

[Insert Figure 2.1 here]

The high annual rate of growth of R&D spending is a clear manifestation of s strong catch-up movement relative to Japan, Russian Federation, European Union, United Kingdom, and United State (Figure 2.2).

[Insert Figure 2.2 here]

A closer look at the data in Table 2.2 suggests that China has made great progress not only on R&D expenditure, but also has a significant increase on R&D personnel in basic research, in applied research, and in experimental development. This can be seen as a consequence of the reforms in the education sector. In addition, the total fund raising for S&T activities increased 4 times from 2000 to 2008, but enterprises are still mainly finance by themselves. China also made a significant achievement in scientific papers issued, publications, and the number of patents, which can be seen as the strengthening of the intellectual property rights legislation.

[Insert Table 2.2 here]

From the perspective of ownership, Table 2.3 presents the various statistics on innovation activities, including R&D, new products, and patents. The most significant feature is that private enterprises are now playing an important role in China's innovation, following by foreign affiliated firms, yet state-owned and collective-owned enterprises are no longer put in a leading position.

[Insert Table 2.3 here]

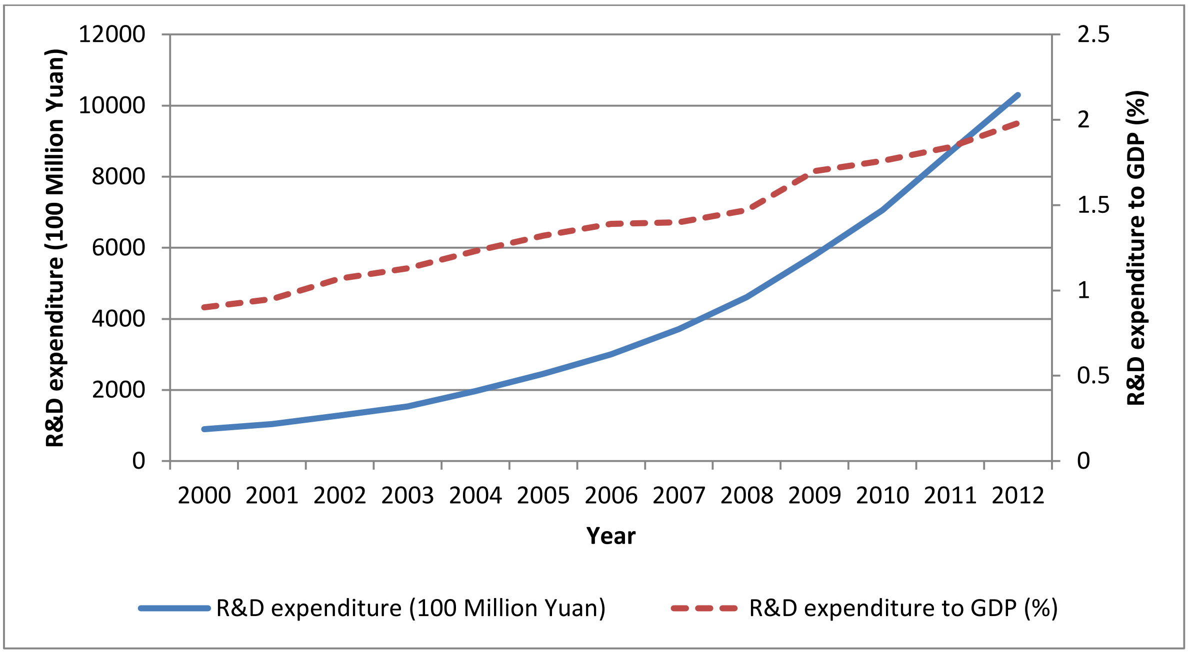
When focusing on industries in Table 2.4, we observe that more than 50% of innovation activities are concentrated in the following 6 high-tech sectors: the manufacture of chemical raw material and chemical products; the manufacture of general purpose machinery; the manufacture of special purpose machinery; the manufacture of transport equipment; the manufacture of electrical machinery & equipment; and the manufacture of communication equipment, computer and other electronic equipment.

[Insert Table 2.4 here]

Chinese enterprises invest in broadly defined innovation in a number of ways. Besides R&D spending, the most notable way is through technology import. China's industrialization since 1949 has relied heavily on the import of foreign technology. This situation has been changed since 2004 (see Panel A in Figure 2.3). For the first time, China's total value of exports of high-tech products exceeded its imports of high-tech products, and this gap is growing larger in recent years, showing the increasing of China's indigenous innovation capacity. Meanwhile, export of high-tech products is taking an increasing proportion in total value of exports (see Panel B in Figure 2.3). These efforts contribute to the change of "Made in China" model to "Create in China" model.

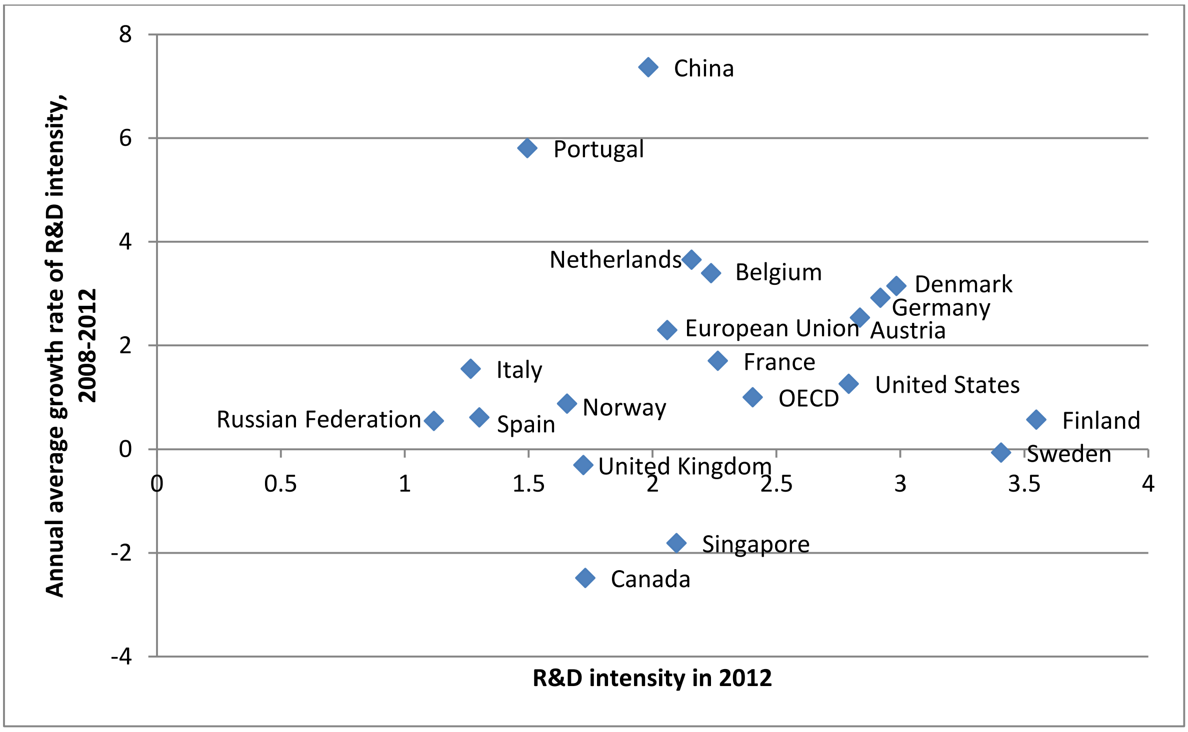
[Insert Figure 2.3 here]

**Figure 2.1: China's R&D expenditure, 2000−2012**




*Sources*: National Bureau of Statistics

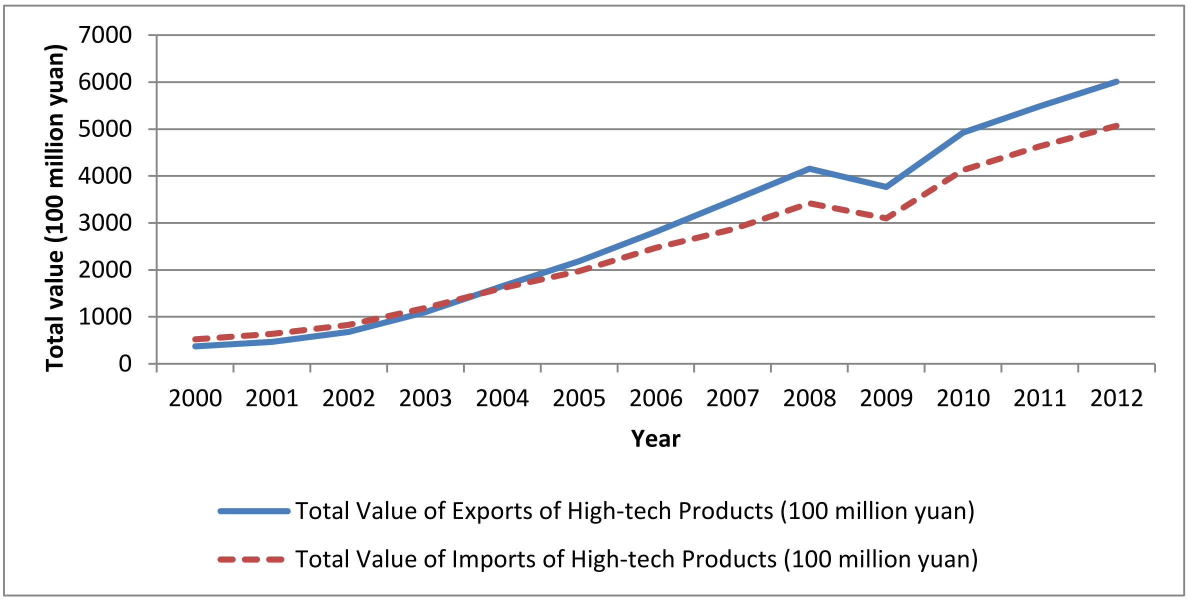
**Figure 2.2: R&D intensity in 2012 and annual average growth rate of R&D intensity, 2008−2012**



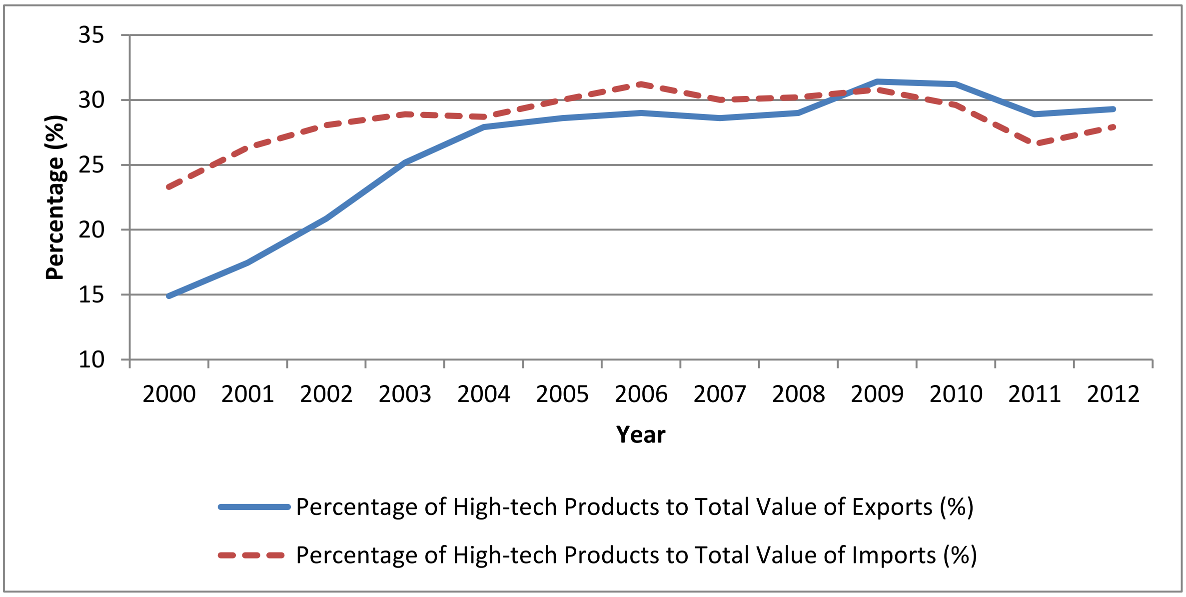

*Sources*: National Bureau of Statistics and OECD

**Figure 2.3: Total value of exports/imports of high-tech products, 2000−2012**

**Panel A:**

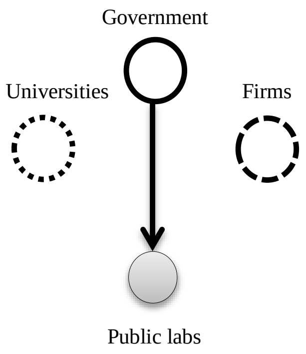
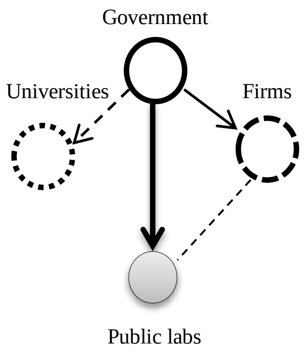
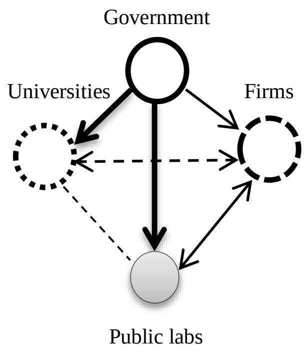
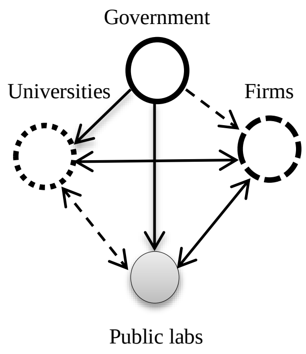
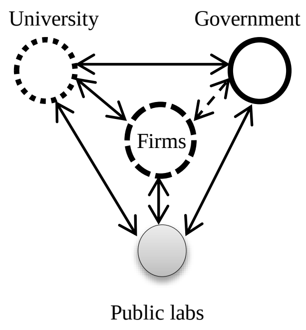



**Panel B:**




*Sources*：National Bureau of Statistics

**Table 2.1: The evolution of China's national innovation system**

| | The pre-reform period (1949−1977) | The experimentation phase (1978−1984) | Structural reform of the S&T system (1985−1994) | Deepening of the S&T reform (1995−2005) | Toward a firm-centered innovation system (2006−now) |
|---|---|---|---|---|---|
| Key innovation policy | ●"The 12-year Plan for Scientific and Technological Development (1956-1967)" | ● "National Plan for the Development of S&T (1978–1985)" | ● "Decision on Reforms of the Science and Technology System"<br>● "Stipulations for Deepening Reforms of the Science and Technology System"<br>● "Torch Program"<br>● "863 Program" | ● "Decision on Accelerating Scientific and Technological Development"<br>● "Decision to Further Reform the S&T System during the Ninth Five-Year Plan"<br>● "Decision on Strengthening Technological Innovation, Developing High-Tech Firms, and Realizing Commercialization of New Technologies" | ● "The Medium- and Long-term Strategic Plan for the Development of Science and Technology (2006−2020)"<br>● "The Decision on Implementing the Medium- and Long-term Strategic Plan for the Development of Science and Technology and Improving Indigenous Innovation Capability" |
| Evolution of the innovation system |  |  |  |  |  |

| | | | | | |
|---|---|---|---|---|---|
| Context | Reconstruction, recovery, and adjustment of the economy | Launch of the reform of the economic system | The reform of the economic system expands into the S&T sphere | Fast economic growth, pressure from technology-based competition in domestic and international markets | Mounting concerns regarding the sustainability of the current growth trajectory |
| Type of learning | Learning from the Soviet model;<br>Learning from self-reflection and criticism | Learning by doing bottom-up experimental reforms | Learning by designing and implementing top-down systemic institutional reforms | Accelerated learning from international good practices fostered by WTO membership and observership in OECD CSTP | Toward endogenous institutional learning and evidence-based policy making, including international benchmarking |
| Policy focus | Remove conceptual/ ideological barriers to S&T development | Address the shortcoming of the Soviet model of an S&T system, especially the lack of science-industry links. Initial reform of the university system | Reform public research organizations (PROs), including the university system and the conversion of public labs specialized in applied research intro business entities | Enhance firms' innovation capabilities & commercialization of public research | Complete the shift from a PRO-centered innovation system to a firm-centered one. Better mobilize S&T for achieving sustainable development |
| Funding instruments | Direct public institutional support | Initial experimental changes of institutional funding, by relaxing the control of funding channels | Reduced public institutional support to applied research in public labs. Launch of the first large public competitive support programmes | Further differentiation of the public support system through the launch of new programmes. Emergence of new publicly sponsored funding channels, e.g. venture capital | Improved mix of instruments to support more efficiently both market-led and mission-oriented S&T development and innovation |

*Source*: MOST and OECD

## Table 2.2: Key indicators of China's innovation progress, 2000−2012

| Indicators | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***R&D personnel*** | | | | | | | | | | | | | |
| Full-time Equivalent of R&D Personnel (100 man-year) | 9,221 | 9,565 | 10,351 | 10,948 | 11,526 | 13,648 | 15,025 | 17,362 | 19,654 | 22,913 | 25,540 | 28,830 | 32,470 |
| Full-time Equivalent of R&D Personnel, Basic Research (100 man-year) | 795 | 788 | 840 | 897 | 1,107 | 1,154 | 1,313 | 1,381 | 1,540 | 1,646 | 1,737 | 1,932 | 2,122 |
| Full-time Equivalent of R&D Personnel, Applied Research (100 man-year) | 2,197 | 2,260 | 2,473 | 2,603 | 2,786 | 2,971 | 2,997 | 2,860 | 2,894 | 3,153 | 3,356 | 3,528 | 3,838 |
| Full-time Equivalent of R&D Personnel, Experimental Development (100 man-year) | 6,230 | 6,517 | 7,039 | 7,449 | 7,633 | 9,523 | 10,714 | 13,121 | 15,220 | 18,114 | 20,446 | 23,373 | 26,509 |
| ***R&D expenditure*** | | | | | | | | | | | | | |
| Expenditure on R&D (100 million yuan) | 896 | 1,042 | 1,288 | 1,540 | 1,966 | 2,450 | 3,003 | 3,710 | 4,616 | 5,802 | 7,063 | 8,687 | 10,298 |
| Expenditure on R&D, Basic Research (100 million yuan) | 47 | 56 | 74 | 88 | 117 | 131 | 156 | 175 | 221 | 270 | 324 | 412 | 499 |
| Expenditure on R&D, Applied Research (100 million yuan) | 152 | 185 | 247 | 311 | 400 | 434 | 489 | 493 | 575 | 731 | 894 | 1,028 | 1,162 |
| Expenditure on R&D, Experimental Development (100 million yuan) | 697 | 802 | 967 | 1,141 | 1,449 | 1,885 | 2,358 | 3,043 | 3,820 | 4,801 | 5,844 | 7,247 | 8,638 |
| Expenditure on R&D, Government Funds (100 million yuan) | | | 398 | 461 | 524 | 645 | 742 | 914 | 1,089 | 1,358 | 1,696 | 1,883 | 2,221 |
| Expenditure on R&D, Self-raised Funds by Enterprises (100 million yuan) | | | 708 | 925 | 1,291 | 1,643 | 2,074 | 2,611 | 3,312 | 4,163 | 5,063 | 6,421 | 7,625 |
| ***R&D Financing*** | | | | | | | | | | | | | |
| Total Fund Raising for S&T activities (100 million yuan) | 2,347 | 2,589 | 2,938 | 3,459 | 4,328 | 5,251 | 6,197 | 7,695 | 9,124 | | | | |
| Total Fund Raising for S&T activities from Government Funds (100 million yuan) | 593 | 656 | 776 | 839 | 986 | 1,213 | 1,368 | 1,704 | 1,902 | | | | |
| Total Fund Raising for S&T activities from Self-raised Funds by Enterprises (100 million yuan) | 1,296 | 1,458 | 1,677 | 2,054 | 2,771 | 3,440 | 4,107 | 5,189 | 6,370 | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Fund Raising for S&T activities from Loans from Financial Institutions (100 million yuan) | 196 | 191 | 202 | 259 | 265 | 277 | 374 | 384 | 405 | | | | |
| ***R&D Achievement*** | | | | | | | | | | | | | |
| Scientific Papers Issued | | | | | | 94 | 106 | 114 | 119 | 136 | 142 | 150 | 152 |
| Publication on S&T | | | | | | 40,120 | 42,918 | 43,063 | 45,296 | 49,080 | 45,563 | 45,472 | 46,751 |
| Number of Major Achievements in S&T (unit) | 32,858 | 28,448 | 26,697 | 30,486 | 31,720 | 32,359 | 33,644 | 34,170 | 35,971 | 38,688 | 42,108 | 44,208 | 51,723 |
| Number of National Invention Prizes Awarded (unit) | 23 | 14 | 21 | 19 | 28 | 40 | 56 | 51 | 55 | 55 | 46 | 55 | 77 |
| Number of National Scientific and Technological Progress Prizes Awarded (unit) | 250 | 191 | 218 | 216 | 244 | 236 | 241 | 255 | 254 | 282 | 273 | 283 | 212 |
| Number of Patents Application Accepted (item) | 170,682 | 203,573 | 252,631 | 308,487 | 353,807 | 476,264 | 573,178 | 693,917 | 828,328 | 976,686 | 1,222,286 | 1,633,347 | 2,050,649 |
| Number of Patents Application Accepted, Inventions (item) | 51,747 | 63,204 | 80,232 | 105,318 | 130,133 | 173,327 | 210,490 | 245,161 | 289,838 | 314,573 | 391,177 | 526,412 | 652,777 |
| Number of Patents Application Granted (item) | 105,345 | 114,251 | 132,399 | 182,226 | 190,238 | 214,003 | 268,002 | 351,782 | 411,982 | 581,992 | 814,825 | 960,513 | 1,255,138 |
| Number of Patents Application Granted, Inventions (item) | 12,683 | 16,296 | 21,473 | 37,154 | 49,360 | 53,305 | 57,786 | 67,948 | 93,706 | 128,489 | 135,110 | 172,113 | 217,105 |

*Note*: Indicator of total fund raising for S&T activities, indicator of total fund raising for S&T activities from government funds, indicator of fund raising for S&T activities from self-raised funds by enterprises, and Indicator of fund raising for S&T activities from loans from financial institutions were abolished in 2009.

*Sources*：National Bureau of Statistics

## Table 2.3: Key indicators of China's innovation on the perspective of ownership, 2012

| | R&D | | | New products | | | | | Patents | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Full-time Equivalent of R&D Personnel (man-years) | Expenditure on R&D (10 million yuan) | Number of R&D Projects (item) | Number of new products (unit) | Expenditure on New Products Development (10 million yuan) | Output Value of New Products (10 million yuan) | Sales Revenue of New Products (10 million yuan) | Export Sales Revenue of New Products (10 million yuan) | Number of Patent Applications (piece) | Number of Invention Patents Applications (piece) | Number of Patents In Force (piece) |
| Industrial Enterprises above Designated Size | 2,246,179 | 72,006 | 287,524 | 323,448 | 79,985 | 1,008,905 | 1,105,298 | 218,942 | 489,945 | 176,167 | 277,196 |
| Domestic Funded Enterprises | 1,651,158 | 54,370 | 223,459 | 247,015 | 57,916 | 661,591 | 727,129 | 90,874 | 379,211 | 135,421 | 209,301 |
| State-owned Enterprises | 162,963 | 5,621 | 20,092 | 20,468 | 5,510 | 78,092 | 73,886 | 3,955 | 30,790 | 11,248 | 16,376 |
| Collective-owned Enterprises | 11,351 | 752 | 2,471 | 1,945 | 588 | 8,042 | 12,245 | 2,660 | 2,750 | 876 | 1,280 |
| Cooperative Enterprises | 6,671 | 239 | 1,320 | 2,862 | 222 | 2,923 | 2,730 | 386 | 1,397 | 451 | 777 |
| Joint Ownership Enterprises | 2,847 | 114 | 225 | 258 | 108 | 1,937 | 1,615 | 54 | 415 | 175 | 142 |
| State Joint Ownership Enterprises | 1,944 | 97 | 133 | 117 | 83 | 1,094 | 1,304 | 43 | 224 | 100 | 59 |
| Limited Liability Corporations | 662,323 | 22,247 | 83,470 | 90,011 | 22,686 | 255,339 | 284,222 | 35,483 | 117,620 | 48,843 | 79,977 |
| State Sole Funded Corporations | 126,402 | 4,521 | 13,737 | 12,941 | 4,478 | 49,167 | 52,525 | 6,546 | 13,942 | 5,412 | 7,829 |
| Share-holding Corporations Ltd. | 371,179 | 12,456 | 41,490 | 45,631 | 13,694 | 169,244 | 181,808 | 27,306 | 78,416 | 33,008 | 53,543 |
| Private Enterprises | 419,112 | 12,465 | 72,299 | 83,612 | 14,625 | 141,787 | 165,428 | 20,534 | 144,168 | 39,626 | 55,726 |
| Other Enterprises | 14,712 | 476 | 2,092 | 2,228 | 482 | 4,226 | 5,196 | 496 | 3,655 | 1,194 | 1,480 |
| Enterprises with Funds from Hong Kong, Macao and Taiwan | 258,541 | 6,724 | 26,417 | 30,947 | 8,124 | 98,746 | 110,068 | 32,377 | 51,434 | 17,426 | 28,136 |
| Hong Kong/Macao/Taiwan Joint-venture Entreprises | 106,372 | 2,836 | 12,059 | 14,098 | 3,301 | 43,941 | 48,377 | 10,932 | 21,480 | 5,729 | 10,962 |
| Hong Kong/Macao/Taiwan Cooperative Enterprises | 3,138 | 79 | 625 | 824 | 117 | 511 | 689 | 202 | 785 | 175 | 825 |
| Enterprises with Sole Fund from Hong Kong, Macao and Taiwan | 132,163 | 3,294 | 11,875 | 13,781 | 4,102 | 46,354 | 52,277 | 19,142 | 25,963 | 10,396 | 14,590 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hong Kong/Macao/Taiwan Share-holding Corporations Ltd. | 15,441 | 474 | 1,596 | 1,919 | 557 | 7,219 | 7,730 | 1,779 | 3,065 | 1,085 | 1,671 |
| Foreign Funded Enterprises | 336,479 | 10,913 | 37,648 | 45,486 | 13,946 | 248,562 | 268,100 | 95,691 | 59,300 | 23,320 | 39,759 |
| Foreign Joint-venture Enterprises | 153,078 | 5,765 | 19,311 | 23,373 | 7,016 | 153,884 | 155,721 | 26,594 | 31,858 | 11,256 | 15,601 |
| Foreign Cooperation Enterprises | 5,152 | 157 | 676 | 740 | 170 | 1,410 | 2,006 | 490 | 865 | 288 | 380 |
| Enterprises with Sole Foreign Fund | 159,290 | 4,360 | 15,745 | 19,086 | 5,923 | 82,264 | 101,112 | 66,093 | 24,283 | 10,696 | 21,639 |
| Foreign-funded Share-holding Corporations Ltd. | 18,075 | 602 | 1,789 | 2,161 | 798 | 10,826 | 8,938 | 2,490 | 2,233 | 1,061 | 2,095 |

*Notes*: Industrial enterprises above designated size means firms with annual revenue from principal business of 20 million yuan and above, which is effective since January 2011. Data for the indicator of Output Value of New Products only update to year 2011.

*Sources*：National Bureau of Statistics

## Table 2.4: Key indicators of China's innovation on the perspective of industry, 2011

| | R&D | | | New products | | | | | Patents | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Full-time Equivalent of R&D Personnel (man-years) | Expenditure on R&D (10 million yuan) | Number of R&D Projects (item) | Number of new products (unit) | Expenditure on New Products Development (10 million yuan) | Output Value of New Products (10 million yuan) | Sales Revenue of New Products (10 million yuan) | Export Sales Revenue of New Products (10 million yuan) | Number of Patent Applications (piece) | Number of Invention Patents Applications (piece) | Number of Patents In Force (piece) |
| Industrial Enterprises above Designated Size | 19,391 | 599,381 | 232,158 | 266,232 | 68,459 | 1,008,905 | 1,005,827 | 202,231 | 386,075 | 134,843 | 201,089 |
| Mining and Washing of Coal | 508 | 14,513 | 4,057 | 1,470 | 504 | 11,255 | 11,156 | 843 | 1,917 | 505 | 606 |
| Extraction of Petroleum and Natural Gas | 324 | 8,213 | 3,610 | 1,043 | 304 | 364 | 593 | 2 | 2,337 | 698 | 954 |
| Mining of Ferrous Metal Ores | 19 | 413 | 191 | 67 | 31 | 318 | 323 | | 301 | 162 | 204 |
| Mining of Non-ferrous Metal Ores | 31 | 1,392 | 373 | 81 | 38 | 681 | 669 | 2 | 193 | 88 | 71 |
| Mining and Processing of Non-metal Ores | 34 | 727 | 350 | 224 | 39 | 542 | 535 | 5 | 145 | 70 | 118 |
| Processing of Food from Agricultural Products | 252 | 9,207 | 3,545 | 3,947 | 1,197 | 14,780 | 14,677 | 1,259 | 4,350 | 1,689 | 1,613 |
| Manufacture of Foods | 196 | 6,261 | 2,917 | 3,007 | 683 | 6,741 | 6,814 | 931 | 3,870 | 1,512 | 1,435 |
| Manufacture of Beverage | 200 | 6,934 | 2,742 | 2,628 | 717 | 8,088 | 7,834 | 215 | 2,174 | 600 | 1,239 |
| Manufacture of Tobacco | 35 | 1,597 | 884 | 800 | 164 | 14,975 | 14,929 | 32 | 1,145 | 381 | 490 |
| Manufacture of Textile | 509 | 13,602 | 6,767 | 7,822 | 1,652 | 33,325 | 32,539 | 6,164 | 12,711 | 1,854 | 1,962 |
| Manufacture of Textile Wearing Apparel, Footwear, and Caps | 172 | 2,895 | 1,141 | 1,452 | 402 | 8,574 | 8,076 | 953 | 3,565 | 345 | 686 |
| Manufacture of Leather, Fur, Feather & Its Products | 80 | 1,544 | 585 | 1,049 | 209 | 5,276 | 5,078 | 1,265 | 2,008 | 214 | 377 |
| Processing of Timbers, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products | 46 | 1,447 | 758 | 821 | 161 | 2,606 | 2,465 | 374 | 1,914 | 541 | 583 |
| Manufacture of Furniture | 50 | 903 | 808 | 1,134 | 130 | 2,579 | 2,549 | 879 | 3,298 | 303 | 1,102 |
| Manufacture of Paper and Paper Products | 153 | 5,589 | 1,602 | 1,512 | 635 | 10,133 | 10,182 | 1,074 | 2,243 | 619 | 809 |
| Printing, Reproduction of Recording Media | 82 | 1,901 | 1,047 | 1,081 | 219 | 2,818 | 2,795 | 212 | 1,281 | 365 | 578 |
| Manufacture of Articles for Culture, Education and Sport Activities | 79 | 1,370 | 1,239 | 1,690 | 172 | 2,096 | 2,080 | 954 | 4,463 | 555 | 1,229 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Processing of Petroleum, Coking, Processing of Nuclear Fuel | 136 | 6,254 | 1,827 | 1,578 | 608 | 11,207 | 11,571 | 37 | 1,055 | 632 | 1,228 |
| Manufacture of Chemical Raw Material and Chemical Products | 1,320 | 46,992 | 18,038 | 17,353 | 4,461 | 65,922 | 64,329 | 6,666 | 18,436 | 9,417 | 11,917 |
| Manufacture of Medicines | 935 | 21,125 | 15,022 | 16,440 | 2,331 | 24,918 | 23,170 | 2,424 | 11,115 | 6,968 | 10,506 |
| Manufacture of Chemical Fibber | 144 | 5,876 | 1,202 | 1,563 | 848 | 13,540 | 12,846 | 1,375 | 2,231 | 560 | 733 |
| Manufacture of Rubber | 182 | 6,313 | 2,812 | 3,310 | 810 | 10,407 | 10,969 | 2,791 | 2,814 | 849 | 999 |
| Manufacture of Plastic | 285 | 7,264 | 3,956 | 9,438 | 919 | 9,623 | 9,209 | 1,670 | 7,735 | 2,055 | 3,393 |
| Manufacture of Non-metallic Mineral Products | 531 | 13,972 | 6,004 | 6,238 | 1,375 | 15,027 | 14,524 | 1,900 | 9,136 | 2,715 | 6,366 |
| Manufacture and Processing of Ferrous Metals | 818 | 51,265 | 7,514 | 7,371 | 5,369 | 68,573 | 68,352 | 5,867 | 8,381 | 2,911 | 4,119 |
| Manufacture and Processing of Non-ferrous Metals | 447 | 19,019 | 4,360 | 4,041 | 1,785 | 35,428 | 34,104 | 3,253 | 6,519 | 2,456 | 4,651 |
| Manufacture of Metal Products | 402 | 11,129 | 5,617 | 6,520 | 1,275 | 15,980 | 15,548 | 2,953 | 12,699 | 2,575 | 4,780 |
| Manufacture of General Purpose Machinery | 1,547 | 40,667 | 22,938 | 27,985 | 5,004 | 59,312 | 59,294 | 7,453 | 33,060 | 8,637 | 13,464 |
| Manufacture of Special Purpose Machinery | 1,465 | 36,566 | 18,396 | 22,362 | 4,580 | 46,175 | 44,792 | 5,094 | 32,022 | 10,300 | 16,358 |
| Manufacture of Transport Equipment | 2,201 | 78,525 | 24,994 | 31,329 | 9,735 | 196,815 | 200,879 | 21,613 | 38,829 | 9,267 | 12,071 |
| Manufacture of Electrical Machinery & Equipment | 2,053 | 62,401 | 27,792 | 32,603 | 7,684 | 115,091 | 109,980 | 23,161 | 57,713 | 16,667 | 24,052 |
| Manufacture of Communication Equipment, Computer and Other Electronic Equipment | 3,180 | 94,105 | 26,552 | 34,672 | 12,358 | 169,691 | 182,268 | 96,386 | 71,890 | 40,980 | 62,159 |
| Manufacture of Measuring Instrument and Machinery for Cultural Activity & Office Work | 616 | 12,087 | 7,990 | 9,802 | 1,483 | 15,121 | 14,584 | 3,160 | 14,059 | 4,319 | 6,759 |
| Manufacture of Artwork, Other Manufacture | 124 | 2,427 | 1,877 | 2,016 | 268 | 3,866 | 3,881 | 1,221 | 3,396 | 612 | 863 |
| Production and Supply of Electric Power and Heat Power | 213 | 4,281 | 2,344 | 1,569 | 265 | 6,610 | 1,800 | 45 | 6,716 | 2,256 | 2,415 |
| Production and Distribution of Gas | 4 | 123 | 65 | 48 | 11 | 185 | 172 | | 63 | 8 | 48 |
| Production and Distribution of Water | 12 | 183 | 141 | 86 | 12 | 23 | 23 | | 197 | 111 | 116 |

*Notes*: Industrial enterprises above designated size means firms with annual revenue from principal business of 20 million yuan and above, which is effective since January 2011. We use the data in 2011 for this table because most of the indicators are only update to year 2011.

*Sources*：National Bureau of Statistics

# Chapter 3

# To what extent do financing constraints affect Chinese firms' innovation activities?

In this chapter, we investigate the extent to which financing constraints affect the innovation activities of over 120,000 unlisted Chinese firms over the period 2000-2007. Based on a variety of specifications and estimation methods, we document that Chinese firms' innovation activities are constrained by the availability of internal finance. Specifically, private firms suffer the most, followed by foreign firms, while state-owned and collective enterprises are the least constrained. Moreover, the availability of internal finance represents a particularly binding constraint on the innovation activities of small firms, located in the coastal provinces, with low political affiliation, and fewer state shares, as well as for sole proprietorship firms.

## 3.1. Introduction

Innovation is a central element of a large number of endogenous growth models and has been widely considered as a key driver of economic growth (Romer, 1990; Aghion and Howitt, 1992). One feature of innovation, its positive “spillovers”, suggests that its privately optimal level is lower than the optimal level from the point of view of the society. Given the high adjustment costs and uncertainty that characterize it, another key feature of innovation is that it is subject to binding financing constraints. This forces a gap between the cost of internal and external finance, which depresses innovation activities, and, consequently, restricts firm growth.

Due to its successful economic transition in the past three decades, China has become a major global participant. In this environment, its innovation system has undergone considerable changes and its innovation performance has improved remarkably. According to OECD reports (2009 and 2010), gross expenditure on R&D (GERD) in China increased consistently from 0.73% of GDP in 1991 to 1.5% in 2008. This growth is even more impressive considering that China’s GDP has simultaneously grown by close to 9% per year on average, and can be seen as a consequence of the reforms in the education sector and the strengthening of the intellectual property rights legislation. The business sector’s share of total R&D expenditure has also dramatically increased, from 30% in 1994 to 70% in 2008. Considering it is the second largest recipient of foreign direct investment (FDI) in the world (since 2004), China has become an attractive country for future R&D investment, and foreign companies have established hundreds of new R&D centers in China in recent years. Furthermore, according to a report of the Chinese Ministry of Commerce, China has become a large exporter of high-tech products, which accounted for 28.9% of its total exports in 2011.

However, China's innovation activities still face considerable challenges. Firstly, China strongly depends on foreign technology. In 2003, foreign-invested enterprises were responsible for 85.4% of China's total volume of high tech exports[3]. As a result, Chinese firms lack core competitiveness and their economic returns are yet to be improved because of weak indigenous innovation capability. Moreover, R&D expenditure as a share of value added remains low in China compared to other countries. Chinese manufacturing sector R&D expenditures made up only 1.9% of total value added in 2004, compared to 7–11% in France, Germany, Japan, Korea, the UK, and the US. In high-tech industries, this ratio in Chinese firms was only 4.6%, compared with around 20% in Korea and close to 30% in Japan, the UK, and the US. In addition, the share of total R&D expenditure allocated to basic research in China is small —only 6%, compared with 14% in both Korea and Russia, and 25% in both the United States and Europe[4].

To promote the further development of innovation, and especially indigenous innovation, firms should increase their R&D expenditure, which can be achieved through government financial support. In 2006, the Chinese government put forward a policy called "The National Medium- and Long-Term Program of Science and Technology Development (2006-2020)", which aimed at strengthening China's scientific and technological (S&T) progress, and achieve an innovation-oriented society by 2020. The most important aspects of this program can be summarized in

[3] Source: National Research Center for Science and Technology for Development, *China Science and Technology Indicators 2004* (Beijing: Science and Technology Publication House, 2005)
[4] Source: "China High-Tech Industry Statistics 2006", China Science and Technology Statistics (STS) website: http://www.sts.org.cn/

three points. First, China committed to increasing R&D expenditure relative to GDP to 2.5% by 2020. Second, it committed to strengthening indigenous innovation, reducing dependence on foreign technology. Third, enterprises and the business sector would be the central driving force of the innovation process, instead of the Ministry of Science and Technology [5].

Although this policy aims at generating positive incentives for Chinese firms' innovation activities, financial constraints have long been considered as the major obstacle for business innovation, especially in transition economies like China. Considering China's relatively poorly developed financial market and state-dominated financial system, we believe that capital and resources are possibly misallocated across firms owned by different agents. Specifically, state-owned enterprises (SOEs) get preferential support from central government and state-dominated banks, finding it easier to obtain finance. However, this lending bias sets up political obstacles for private firms and prevents them from accessing external finance, despite their higher efficiency and faster growth. Huang (2003) describes this phenomenon as a "political pecking order" in the Chinese credit market.

In this chapter, we aim at investigating the relationship between Chinese firms' innovation activities and the possible existence of financing constraints. We first assess whether financing constraints affect Chinese firms' innovation activities, focusing on four ownership types: SOEs, foreign, private, and collective firms. Second, we test the extent to which firm heterogeneity in the terms of firm size, location, political affiliation, percentage of state shares, and organization type is linked with financing constraints binding to different degrees.

[5] See Table 3.A1 in the Appendix for details on the implementation of this programme.

We contribute to the literature along the following three dimensions. First, for the first time in the Chinese context, we test the extent to which financing constraints affect firms' innovation activities. Second, we estimate our regression based on a very large database, compiled by Chinese National Bureau of Statistics (NBS) over the period of 2000−2007. Our database is made up of 120,753 unlisted firms from 31 provinces or province-equivalent municipal cities, which provide up to 745,548 firm-level observations. Third, we take into account various aspects of firm heterogeneity.

Based on a variety of different specifications and estimation methods, we document that Chinese firms' innovation activities are constrained by the availability of internal finance. Specifically, private firms suffer the most, followed by foreign firms, while SOEs and collective firms are the least financially constrained. Moreover, the availability of internal finance represents a particularly binding constraint for the innovation activities of small firms, located in the coastal areas, with low political affiliation and fewer state shares. Last, joint ventures are less likely to face financial constraints than sole proprietorships.

The remainder of the chapter proceeds as follows. Section 3.2 reviews the literature on financing constraints and R&D investment. Section 3.3 introduces our database, and present summary statistics. Section 3.4 puts forward our hypotheses. Section 3.5 illustrates our models and estimation methodology. Section 3.6 describes our main empirical results, while robustness tests are presented in Section 3.7. Section 3.8 concludes.

## 3.2. Literature review

### 3.2.1. Uniqueness of innovation activities

Compared with fixed investment, innovation has the following unique features. First, innovation activities at the firm level generally face high adjustment costs. In practice, about 50% of innovation spending is made up of wages and salaries of research personnel, including highly skilled workers, educated scientists, engineers and other specialists. These types of employees are also characterized by substantial hiring, firing and training costs (Hall and Lerner, 2010). Grabowski (1968) documents that the supply of research workers is not perfectly elastic. These workers cannot therefore be arbitrarily fired during downturns and subsequently rehired. Perhaps more importantly, other serious losses would emerge if fired specialists were rehired by the firm's competitors. Not only would the training spending become sunk, but the rival would imitate inventions and benefit from the transmission of valuable knowledge (Himmelberg and Petersen, 1994). Pakes and Nitzan (1983) point out that firms which make original inventions should provide high wages for highly skilled workers to ensure their retention and avoid setting up a rival. Bernstein and Nadiri (1989) suggest that the marginal adjustment costs of R&D capital are consistently larger than those of physical investment for most industries. Bernstein and Mohnen (1998) conclude that considerable adjustment costs exist in both the US and Japanese innovation intensive sectors.

The second important characteristic of innovation activity is its high degree of uncertainty, generating from its lack of collateral value, irreversibility, long-term returns, and market influence. According to Hall (1992), innovation patents, such as new designs or prototypes, cannot be easily used as collateral, because these innovation processes are likely to be firm-specific and their technology is still under-developed. Furthermore, the costs incurred to undertake innovation activities are normally entirely irreversible, since they are aimed at purchasing experiment-specific equipment and materials, and paying the wages of research personnel (Dixit and Pindyck, 1994). In addition, due to a series of processes characterizing R&D (investigation, preparation, incubation, illumination, verification and application), innovation activities are generally considered as long-term projects. Firms are uncertain about how much effort and materials are ultimately needed to complete each project (Pindyck, 1993). Finally, market demand or acceptance should also be considered as uncertain (Tyagi, 2006). Thus, based on this extreme uncertainty, external financiers, like banks and stock market investors, are reluctant to invest their funds in innovation projects.

### 3.2.2. Market inefficiencies in financing innovation

Innovation is very likely to suffer from market inefficiencies deriving from information asymmetry problems, as the firm carrying out innovation has more information than outside investors on the probability of success and the expected returns of its projects. Anton and Yao (2002) argue that firms are reluctant to fully reveal their potential innovation plans to avoid competitors' imitation. Moreover, accounting rules on R&D expenditure further contribute to information asymmetry (Aboody and Lev, 2000). This makes it hard for external investors to trace changeable information on the value of innovation[6]. Asymmetric information creates an imbalance of power in transactions, which leads to high costs of external financing. Thus, the lender would require higher returns due to the uncertainty of the

[6] Since financial variables should be routinely reported in financial reports, outsiders are periodically informed about the changes in value of most tangible assets and physical investment. In contrast, R&D expenditures are generally recorded as final expense in financial statements.

borrower's payback capability. This implies the supply and the demand of loans cannot reach equilibrium at the market interest rate. Additionally, the absence of organized innovation markets exacerbates the information asymmetries associated with innovation projects. Hence, the market price cannot fully reflect information on the value of innovation projects (Griliches, 1995).

Adverse selection occurs in financing innovation projects when borrowers and lenders suffer from asymmetric information problems. Since innovation ideas are not easily observed, outside lenders cannot know beforehand whether an innovation project is a cherry or a lemon[7]. Harhoff (2000) point out that this will force some potential investors to leave the innovation market due to high risk. In addition, loan size could be below the optimal demand by the borrowers. Finally, standard solutions provided to adverse selection problems, such as signaling, reputation and financial intermediation, are likely to fail in the case of innovation firms (Takalo and Tanayama, 2010).

Asymmetric information also generates moral hazard problems, resulting in conflicts of interest between shareholders and managers. Hall and Lerner (2010) analyze two potential co-existing types of principal-agent conflicts. The first derives from the fact that managers may divert funds towards their private benefit. Restrictions on available cash flow may be an efficient method to reduce this problem. However, this may force managers to finance innovation externally at a higher cost (Jensen and Meckling, 1976). The second conflict is that managers are normally risk averse, especially in dealing with uncertain innovation activities. They try to avoid long-term variance- increasing innovation projects, which might be

[7] A Cherry usually indicates a high quality goods, whereas a Lemon denotes a poor quality good (Akerlof, 1970).

beneficial from a shareholders' viewpoint. The use of long-term incentive contracts can be regarded as an optimal solution to reduce the costs of transacting under asymmetric information (Holmstrom, 1989). Lerner and Wulf (2007) find that long-term incentives lead to either better R&D decisions or more skilled R&D managers and, in turn, more-heavily cited patents.

### 3.2.3. Financing innovation externally

Previous studies suggest that debt finance is not a favorite source of financing for innovation-intensive firms (Chiao, 2002; Bah and Dumontier, 2001; Hall, 1994). Several reasons may explain why this is the case. First, banks are generally risk averse and prefer to finance low risk projects. Second, firms can obtain debt finance from banks on the condition that they have enough collateral used as pledge (Berger and Udell, 1990). Innovative firms cannot satisfy these two conditions because of their high risk and limited collateral value. Third, innovation-intensive firm with high leverage are more likely to suffer from financial distress (Opler and Titman, 1994), which puts bank off lending to them. Fourth, a stable stream of cash flow is one of the most important requirements for obtaining bank loans, and is difficult to achieve for innovation-intensive firms, due to the high adjustment costs they face. Debt finance is therefore not an appropriate source for financing innovation, even though it is useful to finance physical investment. In line with these arguments, Hall (1992) finds a significantly negative correlation between leverage ratios and R&D investment. Similarly, Hall (2002) reports that R&D-intensive firms normally exhibit lower debt ratios than that of other firms. Finally, Brown et al. (2012) confirm debt plays no effect in financing innovation activities.

Compared to cash flow and debt, equity-based finance is believed to be the most costly source of financing since investors require a higher expected rate of return to compensate for the “lemon” risk. However, in practice, innovative firms prefer to issue stocks to finance investment for the following reasons. First, shareholders achieve enormous profits if the innovation succeeds. Second, shareholders can monitor managers internally, which could reduce moral hazard problems. Third, there are no collateral requirements. Finally, stock issues do not magnify problems associated with financial distress (Brown et al., 2012). These advantages of equity finance imply that external stock issues may be an efficient way of financing innovation. In an empirical study of 38 countries, Kim and Weisbach (2008) suggest that equity plays an important role in raising capital for investment, and the effect is stronger for R&D spending than fixed investment. A significant effect of stock issue in financing innovation can also be found in Brown and Petersen (2009), Brown et al. (2009) and Brown et al. (2012).

Recently, evidence shows that other external funds, such as venture capital (Gompers, 1995; Cochrane, 2005) and FDI (Girma et al., 2008; Li et al., 2010) are alternative sources for financing innovation activities.

### 3.2.4. Empirical tests on the effects of financing constraints on innovation activities

Several authors have tested for the existence of financing constraints by examining the effect of a change in cash flow on firms’ activities. If a firm is financially constrained and its cash flow drops, it will have to cut back its investment, inventory accumulation, and other activities, as it is unable to access the more expensive external financing. If, on the other hand, the firm is financially healthy, a drop in its cash flow should not affect its investment behavior, as it can always replace the lost internal finance with bank loans or other forms of external finance. This methodology for testing the presence of liquidity constraints was pioneered by Fazzari et al. (1988), who focused on corporate fixed investment. Subsequent studies have supported this argument (Hubbard, 1998; Bond and Van Reenen, 2007).

Recently, this idea has been used in testing the effects of financing constraints on innovation activities (Hall, 1992; Brown et al., 2009). Specifically, several researchers have investigated the presence of financing constraints on innovation activities in different markets, such as the US, the UK, Japan, France, Germany and other European countries. Most of these studies use firm-level data and analyze the sensitivity of R&D expenditure to cash flow. For instance, Hall (1992) uses a large sample of publicly traded manufacturing US firms from 1973 to 1987 and identifies a significantly positive association between R&D investment and cash flow based on a dynamic accelerator model. A similar relationship is found by Himmelberg and Petersen (1994), who use a panel of 179 small firms in high-tech industries in the US, and by Harhoff (2000), who focuses on a panel dataset of German manufacturing firms and an Euler equation model. Similar results are also obtained for other countries, such as Ireland (Bougheas et al., 2003), Belgium (Cincera, 2002), and the Netherlands (Tiwari et al., 2007). In addition, Hall et al. (1999) and Mulkay et al. (2001) find that R&D investment is more sensitive to cash flow in the US than in France and Japan.

More recently, Brown et al. (2009) analyze the financing of R&D by using US firm-level data over the period 1990-2004. Based on the results from the estimation of an Euler equation, they find that the financial variables are significantly associated with the innovation activities of young firms. Brown and Petersen (2009) report that investment-cash flow sensitivities remain relatively strong for R&D investment even if they largely disappear for physical investment and decline for total investment. Brown and Petersen (2011) analyze cash holdings and R&D smoothing in the US manufacturing firms over the period 1970-2006. They find that firms most likely to face financing constraints rely on cash reserves to smooth their R&D expenditures.

By contrast, a handful of papers support the idea that firms' innovation activities are financially unconstrained. Bhagat and Welch (1995) demonstrate that past operating cash flow is not significantly correlated with current R&D spending in the US, the UK, Canada, Europe and Japan. Using an Error Correction model, Bond et al. (2003) find that cash flow appears not to be important for the level of R&D spending neither for German firms nor for British firms. For the UK, they find that the sensitivity of cash flow to fixed investment for non-R&D participating firms is greater than that for R&D performing firms.

## 3.3. Hypotheses

### 3.3.1. General hypothesis

Previous research found significant effects of financing constraints on innovation activities in developed countries such as the US, the UK, and other European countries. However, to the best of our knowledge, no paper has tested for the presence of these effects in the Chinese context. In recent years, a few papers have started to study the effects of financing constraints on Chinese firms' fixed investment and growth (Héricourt and Poncet, 2009; Guariglia et al., 2011; Poncet et al., 2010). Due to the imperfection and underdevelopment of the Chinese capital market, we believe that Chinese firms' innovation activities are likely to suffer from significant asymmetric information problems. We therefore hypothesize that:

***H1:*** *Due to the underdevelopment and imperfection of the Chinese capital market, Chinese firms' innovation activities are likely to be constrained by the availability of internal financing.*

### 3.3.2. Hypothesis on firm ownership

Guariglia et al. (2011) find that the growth of private firms' assets is most affected by the availability of internal cash flow, while that of SOEs and collective firms is least affected. This argument is supported by other recent research which focuses on corporate fixed investment, such as, for instance, Naughton (2007), Héricourt and Poncet (2009), and Poncet et al. (2010). A lending bias has long existed in China due to the state-dominated financial system. Since their establishment in the late 1970s, the "Big Four" state-owned commercial banks have always been dominant players in the Chinese financial market[8]. Before 1998, according to the credit quota system, banks were only allowed to allocate loans to state firms, thus private firms were not legally recognized by formal financial markets. Although this credit quota system was abolished by the People's Bank of China (PBC) in 1998, the lending bias has not been fully alleviated and still has some effects on financing. As a result, we

[8] The "Big Four" consist of the following four specialized state-owned banks: the Bank of China (BOC), the Agriculture Bank of China (ABC), the Construction Bank of China (CBC), and the Industrial and Commercial Bank of China (ICBC).

would expect SOEs to continuously take advantage of superior financing accessibility, therefore suffering less or not at all from financial constraints.

Although Héricourt and Poncet (2009) and Poncet et al. (2010) find little effects of financing constraints on foreign firms' fixed investment, Guariglia et al. (2011) find foreign firms' growth is significantly constrained by cash flow. They explain this considering that, as documented in World Bank (2006), fully foreign owned firms operating in China have limited access to domestic direct finance, and have to finance much of their investment from abroad. This leads to the following hypothesis:

***H2:*** *The effect of financing constraints on innovation activities is likely to be larger and more significant for private firms and foreign firms than for SOEs and collective firms.*

### 3.3.3. Hypothesis on firm heterogeneity

#### *3.3.3.1. Size*

Size has been widely used as a proxy for external financial constraints on firms' fixed investment (Guariglia, 2008), and for innovation activities (Hall and Lerner, 2010; Czarnitzki and Hottenrott, 2011). It is suggested that investment by small firms is significantly constrained by accessibility to external finance because these firms are particularly susceptible to information asymmetry effects. Small firms are also disadvantaged as they cannot exploit scale economies and have fewer overall physical assets that could serve as collateral compared to large capital intensive companies. Thus, they have fewer funds to finance their innovation projects. In addition, bank financing may be limited for innovation projects of small firms because of their high default risk. We therefore expect more significant effects of financing constraints on innovation activities in small firms than large firms, i.e.:

***H3a:*** *Small firms' innovation activities are more likely to be subject to financial constraints than those of their large counterpart.*

#### *3.3.3.2. Location*

Due to the technological advancements and open-door policy, firms located in China's eastern regions experienced fast growth in the past three decades, giving rise to a divergence in development between the coastal and inner regions. In order to balance the development in different regions, the Chinese government implemented the "China's Go-West Campaign" and the "Rise of Central China" policy. Firms operating in central and western areas may benefit from financial incentives from these policies. In contrast, firms in the eastern regions are more likely to be severely financially constrained, due to high competition for a limited pool of funds (Guariglia et al., 2011). Therefore, we believe firm's innovation activities will be more financially constrained for firms located in the coastal region. This leads to the following hypothesis:

***H3b:*** *The innovation activities of firms located in the coastal region are more likely to be financially constrained than those of firms located in the western or central regions.*

#### *3.3.3.3. Political connections and percentage of state shares*

*Guanxi* is a concept which means drawing a web of connections in personal or business relations. In recent years, it has permeated every corner of the Chinese society. Due to the social embeddedness of business relations in China, *guanxi* can not only help to increase the efficiency and effectiveness of daily business operations, but also represent an essential informal governance mechanism that helps create social and economic value for organizations. Firms affiliated with the central or provincial governments have good *guanxi* with the government, and may benefit from obtaining funds as the banking system is dominated by the state. In addition, Gu et al. (2008) find firms can improve market access, growth and performance through *guanxi* networks, and better performance makes it easier for these firms to obtain external finance, making them less financially constrained. Similarly, firm with some percentage of state ownership may also have better *guanxi* relationships with the government, and may benefit from this, thus facing less financial constraints. This leads to the following hypothesis:

***H3c:*** *The innovation activities of firms that are not affiliated with the central or local governments and have no state ownership are more likely to be financially constrained than those of politically affiliated firms with some degree of state ownership.*

#### *3.3.3.4. Organizational structure*

Joint-ventures serve as a vehicle combining the organizationally-embedded learning between firms. Product innovation can be seen as an outcome of joint ventures' combinative capabilities, reflecting how well they collaborate in improving operational efficiency and effectiveness, and in building new competences (Kogut and Zander, 1993). Joint ventures generally exhibit better performance (Greenaway et al., 2014) and are more likely to export (Manova et al., 2011) than sole proprietorship firms. There are several joint-ventures in China, taking advantage of shared resources and information, regulatory permits and approvals, tax deductions, risk distribution, cultural difference, and financing opportunities. In addition, a joint venture partnership is often considered because it is less expensive for foreign firms to enter the Chinese market through the formation of a joint-venture than by building from scratch. Joint-ventures are therefore likely to be less financial constraints than sole proprietorship firms. We therefore hypothesize that:

***H3d:*** *Joint venture firms are less likely to face financial constraints on their innovation activities than sole proprietorship firms.*

## 3.4. Data and summary statistics

### 3.4.1. Sample construction

This study uses data taken from the annual accounting reports, maintained and compiled by the NBS (National Bureau of Statistics of China) over the period 2000−2007. The census database provides information for large- and medium-sized Chinese industrial firms with annual sales of more than five million Yuan (about $650,000). The advantage of a firm-level dataset is that it eliminates aggregation problems in estimation. Additionally, moving beyond a representative firm framework, it is possible to take firms' heterogeneity into account (Bond and Van Reenen, 2007).

Regarding the measure of ownership, the NBS data contains six different types of investors defined on the basis of their paid-in-capital: the state; foreign investors (excluding ones from Hong Kong, Macao and Taiwan); investors from Hong Kong, Macao and Taiwan; legal entities; individuals; and collective investors[9]. Foreign investors from Hong Kong, Macao and Taiwan include "Round-Tripping" FDI[10]. Legal entities are a form of corporate ownership, which mixes state legal persons and private legal persons. Managed by local governments, collective firms are typically owned collectively by communities in rural areas (known as Township and Village Enterprises or TVEs) or urban area (known as Urban Collective Enterprises or UCEs). We group our firms into four categories, namely state owned; foreign owned (merging firms from Hong Kong, Macao, Taiwan and firms from other parts of the world together); privately owned (which include legal entities and individual firms); and collectively owned. Specifically, these four categories are classified based on majority (at least 50%) average ownership shares[11].

In order to ensure the reliability of our analysis, we first drop observations which make little sense, such as those with a negative value of sales and negative new product sales. Observations with negative values of total assets minus total fixed assets; observations with negative values of total assets minus liquid assets; and observations with negative values of accumulated depreciation minus current

[9] We prefer to classify ownership based on the fraction of capital paid- in by the various groups in every year, rather than using registration codes. One reason for the choice is that there are substantial delays in updating firms' registration codes, which in fact makes these codes unreliable. Another reason is that firms might have an incentive to falsely register as foreign firms, in order to take advantage of the benefits granted to these firms.

[10] "Round-Tripping" FDI (Foreign Direct Investment) indicates that part of FDI to China belonging to the return of Chinese capital. In order to take advantage of benefits, such as tax preferential policy, property rights protection, loose exchange controls and competitive financial services, domestic capital goes abroad and is later re-invested back, registered as foreign invested capital in the form of FDI (Huang, 2003; Xiao, 2004).

[11] Our results were robust to using a 100% rule to define ownership. According to such rule, a firm is defined as, for instance, foreign if 100% of its capital is paid-in by foreign agents. Results using this alternative way of defining ownership are not reported for brevity, but available upon request.

depreciation are also taken out of our sample. Second, we exclude firms without complete records on our main regression variables. Third, in order to control for extreme values, we drop outliers, defined as the 1% and 99% tails of the distribution of our main regression variables[12]. After the above adjustments, our final panel data set includes 745,548 firm-level observations, covering 120,753 unlisted firms over the period 2000−2007.

We define innovation activities as the ratio of a firm's sales of new products to total assets. According to the NBS, new products are defined as "those [products] new to the Chinese market, which either adopt completely new scientific principles, technologies, or designs or are substantially improved in comparison with existing products in terms of performance and functionality, through significant changes in structure, materials, design, or manufacturing processes" (China Statistical Yearbook, 2006). A firm's new products are subject to local governments' certification, which is generally valid for up to three years. New product sales have been widely used in recent research papers to represent firms' innovation activities. As they represent the output of firms' innovation activities, they are believed to be a more suitable measure than R&D, which is simply an input into the innovation process (Criscuolo et al., 2005; Girma, Gong and Gorg, 2008). In addition, the McKinsey survey (McKinsey & Co., 2008) suggests that product innovation is the indicator most used by companies to track innovative performance. Moreover, according to recent changes in the Chinese accounting system, R&D expenditure is only directly disclosed after 2005 (Li, Chen and Shapiro, 2010)[13], while new product sales are available throughout our sample (with the exception of 2004). We therefore use new

[12] For new product sales, we only trim 99% tails of the positive values because this variable is censored at zero.
[13] All our results are robust to using R&D expenditures as the measure of innovation activity (see Table 3.8).

product sales to total assets to measure firms' innovation activities, and call this variable product innovation.

Table 3.1 presents the distribution of the innovation participation rate by year, industry, and ownership type. We observe that on average, only around 10% of our firm-year observations are involved in innovation activities, i.e. have non-zero new product sales. This can be explained considering the high adjustment costs and uncertainty that characterize innovation activities. However, the innovation participation rate in SOEs is much higher than in other groups of firms, reaching to 15.91%. This is because SOEs generally operate in important industries and key areas which relate to national security. Thus, their innovation is essential for updating national industries and improving Chinese competitiveness. In addition, SOEs are supported by the government and can easily obtain money from state banks, or finance form external capital market. The innovation participation rate in foreign firms is much lower (6.85%), probably because of the relatively weak innovation environment in China, and of less developed capital markets and restrictions of market admittance for foreign firms. Private firms' average innovation participation rate is 10.94%, which is higher than that of foreign firms, but lower than that of SOEs. This shows their enthusiasm for innovation, but suggests that, at the same time, financing constraints may create obstacles for their innovation activities. The innovation participation rate is visibly low in collective firms (5.68% on average), probably because this type of firms are controlled by local government in rural areas or urban areas, and their main interest lies is maintaining local employment levels instead of increasing competition against other firms.

[Insert Table 3.1 here]

Looking at innovation participation rates over time, we initially observe a decline from 10.08% in 2000 to 7.86% in year 2003. The innovation participation rate then rises to reach 12.33% in 2006 and 12.19% in 2007. The initial decline in innovation can be explained by the effects of the collapse of the Information Technology Bubble, which took place in 2000. The innovation incentive policies after 2003 may explain the subsequent recovery of the innovation participation rate. We observe a similar trend for SOEs, foreign, private and collective firms. However, private firms' participation rate increases the most. This is symptomatic of strong growth in private firms.

Looking at the distribution of the innovation participation rate by industry, we observe that innovation activities are concentrated in high-tech industries, such as Chemical & Plastic, Machinery & Equipment, Electrical Equipment, and Transport Equipment (with rates of 11.90%, 17.09%, 16.35%, and 18.18%, respectively). The innovation participation rates in other industries are all below 10%. In addition, SOEs and collective firms prefer innovating in Electrical Equipment, and foreign firms prefer Machinery & Equipment, while private firms innovate more in Transport Equipment.

### 3.4.2. Summary statistics

Table 3.2 presents descriptive statistics (sample means and medians) for firms with new products, and firms without. We observe that non-innovative firms have a higher average sales to assets ratio (166.44%) and a higher average cash flow ratio (8.29%) than their non-innovative counterparts (for which the corresponding figures are 124.39% and 7.60%). New long-term debt issues are both small and not statistically different for the two groups. However, innovative firms are generally larger and older, in terms of average total assets (410.51 million of yuan) and average age (16.88 years), compared to non-innovative firms (for whom the corresponding figures are 80.96 million of yuan and 10.98 years). This can be explained considering that large and old firms are more likely to be financially unconstrained, thus have more capacity to participate in innovation. Moreover, innovative firms have faster sale growth (14.48%), assets growth (11.02%), and employee growth (2.16%), compared to 12.11%, 10.09%, and 1.71% for non-innovative firms. This indicates their huge potential. Because of large number of highly skilled workers, innovative firms have higher labor productivity (372.74%) and higher wages per employee (16.66), compared to figures of 308.66% and 13.53 for non-innovative firms.

[Insert Table 3.2 here]

As regards to financial variables, the leverage ratio is slightly but still significantly higher in innovative firms: 58.63% compared to 57.73% for the non-innovative firms. This reveals a higher borrowing capacity for innovative firms, which may be due to their larger size. In addition, the higher liquidity ratio (6.49%) characterizing innovative firms, suggests they are more financially healthy than their non-innovative counterparts, whose liquidity ratio is only 5.89%. The difference in the coverage ratio between innovative and non-innovative firms is not statistically significant.

In terms of China-specific variables, innovative firms prefer to locate in the east, and they are characterized by more state shares and high political affiliation than their non-innovative counterparts.[14]

Table 3.3 provides a comparison of our main variables across firms owned by different agents. Despite being small in terms of average total assets (75.99 million of yuan) and young (9.66 years), private firms exhibit the highest new products sales to assets ratio, sales to assets ratio, sales growth, and assets growth, respectively 5.26%, 179.26%, 13.75%, and 12.11%. This indicates that private firms are not only the most active in the Chinese economy, but also shows their enthusiasm for innovation activities.[15] Their high new products to assets ratio is possibly supported by the high cash flow ratio (8.50%) that these highly productive firms have been able to accumulate. Private firms' labor productivity is 298.32, which is much greater than that of SOEs (179.10). It is interesting to note that private firms are the only group with a positive new long-term debt issue ratio (0.11%). This reflects that they have to borrow external funds to support their innovation activities when their internal cash flow is exhausted.

[Insert Table 3.3 here]

Foreign firms also exhibit a high cash flow to total asset ratio (8.71%), but a negative new long-term debt issue ratio (-0.04%), probably because they prefer to access external finance from their home country. In addition, they are the youngest

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[14] See the Appendix for complete definitions of all variables. It should be notes that a higher value of the political affiliation figure indicates lower political affiliation.

[15] According to the key indicators of China's innovation on the perspective of ownership in 2012 (see page 25), private enterprises have higher number of R&D projects, number of new products, and number of patent applications than state-owned enterprises, collective-owned enterprises, and foreign funded enterprises. All these evidence indicates that private firms have the highest innovative activities in China. However, due to high levels of asymmetric information and agency costs, and due to high competition for a limited pool of funds, private firms are more likely to be severely financially constrained.

group in China, with average age of 8.24 years. Most of foreign firms entered China after 1990s and started to participate in innovation activities even later. However, their high labor productivity (429.11) indicates that they are the most efficient in China. This is due to their more advanced management practices and technology. In addition, their high wage per employee (19.91) is likely to attract more people, explaining their high employee growth of 5.04%. As regards to financial variables, foreign firms exhibit the highest liquidity (15.52%) and coverage ratio (27.46%), indicating they are more financially healthy.

SOEs are typically large (with average total assets of 392.56 million of yuan) and old (with average age of 28.61 years). They display high leverage (68.42%), negative liquidity (-5.91%), and a low coverage ratio (0.93%), which indicate they are likely to benefit from soft budget constraints.

In terms of China-specific variables, private and foreign firms are more likely to locate in the coastal area, while most SOEs are in the central core. Compared to foreign firms, private firms have a higher percentage of state shares and are more likely to be politically affiliated. Collective firms, managed by local government, behave similarly to SOEs, with respect to most of the variables in the table.

## 3.5. Models and methodology

### 3.5.1. Baseline models

We explore the impact of financial variables on innovation activities (new product sales) based on an Euler equation similar to that used by Brown et al. (2009) and Brown et al. (2012). This approach is a modified version of the fixed investment model used by Whited (1992), Bond and Meghir (1994), and Bond et al. (2003). The Euler equation is a structural model, explicitly derived from the dynamic optimization “Euler condition” for imperfectly competitive firms that accumulate productive assets under the assumption of symmetric, quadratic adjustment costs. Bond et al. (2003) report a significant advantage of this specification “under the maintained structure, the model captures the influence of current expectations of future profitability on current investment decisions; and it can therefore be argued that the current or lagged financial variables should not enter this specification merely as proxies for expected future profitability”.

In the absence of financing constraints, the Euler equation leads to the following empirical specification:

$$npa_{i,t} = \beta_1 npa_{i,t-1} + \beta_2 npa^2_{i,t-1} + \beta_3 sa_{i,t-1} + \beta_4 cfa_{i,t-1} + \beta_5 dbta_{i,t-1}$$

$$+v_i + d_t + \varepsilon_{i,t} \tag{3.1}$$

where $npa_{i,t}$ is new product sales normalized by total assets for firm $i$ in period $t$; $sa_{i,t}$ is the firm’s sales to total assets; $cfa_{i,t}$, the firm’s cash flow to total assets; and $dbta_{i,t}$, the firm’s long-term debt issue to total assets. $v_i$ represents the firm-specific component of the error term; $d_t$ denotes a time-specific component; and $\varepsilon_{i,t}$ is an idiosyncratic component.

The empirical model above is the same as that estimate in Brown et al. (2009), Brown et al. (2012), and Martinsson (2010), except for the fact that we replaced stock issue with long-term debt issues to capture firms’ external finance. This is because our data consists of unlisted firms, which do not issue equity.

The parameters in Equation (3.1) can be interpreted as functions of the parameters of the original optimization problem, which underlies the Euler equation (see Brown et al., 2009). The structural model implies that the coefficient on lagged new products to assets ratio ($\beta_1$) should be positive and slightly larger than 1. Under the assumption of quadratic adjustment cost in the Euler condition, the coefficient on lagged new products squared ($\beta_2$) should be negative and slightly lower than -1. The lagged sales to assets ratio ($\beta_3$) should have a positive coefficient under perfect competition. The lagged cash flow to assets ratio appears in the specification to account for the cost of other factors of production, under constant returns to scale, under the assumption that the marginal products of other factors equal their costs. As such, cash flow enters the specification even without financing constraints, but the structural model implies that, in the absence of financing constraints, the coefficient $\beta_4$ has a negative sign. Observing a positive instead of a negative $\beta_4$ coefficient could therefore be an indicator of the presence of liquidity constraints. Finally, the external debt coefficient ($\beta_5$) should enter non-significantly.

For robustness, we subsequently augment the baseline Euler specification by adding contemporaneous terms. The modified Euler equation is:

$$npa_{i,t} = \beta_1 npa_{i,t-1} + \beta_2 npa_{i,t-1}^2 + \beta_3 sa_{i,t} + \beta_4 sa_{i,t-1} + \beta_5 cfa_{i,t} + \beta_6 cfa_{i,t-1}$$

$$+ \beta_7 dbta_{i,t} + \beta_8 dbta_{i,t-1} + v_i + d_t + \varepsilon_{i,t} \qquad (3.2)$$

We include contemporaneous cash flow which is the standard measure of internal financing in the financing constraints literature. Considering the correlation between sales and cash flow, we also add contemporaneous sales as an additional control for firm demand, in order to avoid possible omitted variable bias. Moreover, we add contemporaneous long-term debt issues as an additional control for firms' external financing. As in Equation (3.1), all the variables are scaled by total assets.

### 3.5.2. Estimation methodology

A noteworthy feature of our data is that a large number of Chinese firms in the sample do not have new products. A firm either innovates (in which case, $npa_{i,t}>0$) or it does not (in which case $npa_{i,t}=0$). Thus, our dependent variable can only be partially observed. This feature would lead an OLS regression to deliver inconsistent parameter estimates because the sample is not representative of the whole population. We therefore use the Tobit model in estimation (Tobin, 1958). The model is estimated by a maximum likelihood method, which yields consistent estimators for the model parameters. In order to control for unobserved heterogeneity and potential endogeneity of cash flow, we also use random effects Tobit estimator and an IV Tobit estimator.

The coefficients obtained from Tobit estimation cannot be directly interpreted as the effect of changes in the independent variables on the dependent variable. Instead, they should be interpreted as the combination of a probability effect and a quantity effect. We first generate the marginal effect of the explanatory variables on the probability that a firm will have positive new product sales. We then calculate the marginal effect of a change in the explanatory variable on expected new product sales, given that the observation has not been censored. These marginal effects take into account the censored nature of the response variable.

## 3.6. Empirical results

### 3.6.1. Regression results for the full sample

Table 3.4 shows regression results of the baseline (Equation 3.1) and augmented (Equation 3.2) specifications of the Euler equation for the full sample by using different estimators: the pooled Tobit, random effects Tobit and IV Tobit. A total of 263,272 observations are left-censored, which indicates these firms have no sales generated from new products. Only 33,923 observations are uncensored, revealing the relatively low level of innovation capacity of Chinese firms[16]. Focusing on the baseline specification, we focus on the coefficient and marginal effects associated with the lagged cash flow term. According to the Euler equation theoretical model, we should observe a negative relationship between new product sales and lagged cash flow under the assumption of perfect capital markets without credit constraints. However, if lagged cash flow is significantly positively related to new product sales, this suggests firms' innovation activities are subject to financial constraints. Our regression results consistently show that the lagged cash flow estimates in the baseline specification are all positive and statistically significant. This finding does not conform to the predictions of the structural model. This suggests that, in line with our Hypothesis 1, Chinese firms' innovation activities are constrained by the availability of internal finance. As regards to marginal effects, a unit standard deviation rise in the cash flow ratio increases the probability of firms being involved in new product sales by 0.016%, 0.028%, and 0.050%, respectively when using the pooled Tobit, random effects Tobit, and IV Tobit estimators. On the other hand, taking the censored nature of our response variable into account, one standard

[16] There are fewer observations in those specifications in which the IV Tobit model in used because we instrument current sales and current financing variables using their own values lagged twice.

deviation increase in the cash flow ratio enhances new product sales respectively by 1.316%, 2.295%, and 4.068%.

[Insert Table 3.4 here]

Focusing on the coefficients of the other regressors, we note that in baseline Euler equation, the coefficients on lagged new product sales are all significantly greater than 2, indicating fast growth of innovation in China. The coefficients on lagged new product sales squared are negative and statistically significant, but greater than predicted by the Euler condition. The coefficients on lagged sales are significantly negative, while the predicted sign should be positive. Finally, the coefficients on the lagged long-term debt issues are not significant, suggesting debt is not a preferred channel to finance Chinese firms' innovation activities.

By inspecting the augmented specification, the coefficients of contemporaneous cash flow are all significant and positive, but the lagged cash flow estimates are poorly determined. This is consistent with the findings in Brown, Fazzari and Petersen (2009). However, the sums of all cash flow terms are still significantly positive, suggesting an economically important effect of cash flow on innovation activities. As for marginal effects, the probability effects (for the latent dependent variable) are 0.025%, 0.041%, and 0.056%, and the quantity effects (for uncensored observations) are 2.099%, 3.441%, and 4.732%, when using the pooled Tobit, random effects Tobit, and IV Tobit estimators, respectively. These findings can be viewed as the first evidence that Chinese firms' innovation activities are financially constrained, providing support for our Hypothesis 1. This indicates that Chinese firms are generally constrained by their internal finance, and it is difficult and expensive for them to obtain financial support externally. The gap between the cost of internal and external finance may depress innovation activities, and, consequently, restricts firm growth. We next look at whether the estimation of innovation activities and cash flow differ for firm owned by different agents.

### 3.6.2. Regression results for firms owned by different agents

Table 3.5 presents estimation results of the baseline specification of the Euler equation (Equation 3.1) for firms owned by different agents, namely SOEs, foreign, private, and collective firms. The coefficient on lagged new products, lagged new products squared, lagged sales, and lagged long-term debt issues in different groups are similar to those obtained using the full sample. However, the lagged cash flow estimates are different. Specifically, the coefficient is significantly positive for foreign and private firms, but not for SOEs and collective firms. These results indicate that foreign and private firms' innovation activities are subject to financing constraints, whereas SOEs and collective firms are not. We also observe that the lagged long-term debt issue estimates are poorly determined for all ownership groups.

[Insert Table 3.5 here]

Considering that they benefit from tax incentives for innovation spending, direct grants aimed at specific innovation activities, and government subsidies, SOEs are likely to have sufficient funds to support their innovation activities. This explains why their innovation activities are less financially constrained than those of other firms. In addition, despite the banking reforms in the last 30 years, the state dominated banking system continues to lend to state-owned enterprises, regardless of performance. This prevents SOEs to go bankrupt and avoids mass unemployment. Further evidence on this is given by Boyreau-Debray (2003) who state that, although SOEs only account for less than one quarter of industrial output, they absorb three quarters of lending from banks in the late 1990s. This lending bias again reflects the fact that the Chinese government uses bank credit as a political instrument to stimulate the state sector. Similarly, the lagged cash flow coefficient is insignificant and poorly determined also for collective firms, given their close relationship with local governments.

The coefficients on the lagged cash flow are significantly positive and precisely determinate for foreign and private firms, indicating that their new product sales are restricted by the availability of internal finance. By inspecting the marginal effects on the lagged cash flow coefficients using the pooled Tobit estimator, we observe that a unit standard deviation rise in the cash flow ratio increases the probability of a firm being involved in innovation by 0.025% and 0.057% for foreign and private firms, respectively. In addition, a unit standard deviation increase in the cash flow ratio enhances new product sales of firms selling new products by 3.063% for foreign firms and by 4.808% for private firms. These results indicate that private firms' new product sales display higher sensitivities to cash flow than those of foreign firms. Private firms' innovation activities are therefore more constrained by the availability of internal finance than those of foreign firms. Together with the insignificance of the lagged cash flow coefficients for SOEs and collective firms, our findings suggest that private firms' innovation activities are the most like to face financing constraints, followed by foreign firms, while SOEs and collective are the least financially constrained. These results are robust to using the random effects Tobit estimator and the IV Tobit estimator, and provide support for our Hypothesis 2.

Table 3.6 presents estimates of the augmented specification of the Euler equation (Equation 3.2). To economize on space, we only report the sums of the coefficients on the financial variables. Consistent with the findings in Table 3.5, the coefficients on the sum of the cash flow terms are significantly positive for foreign and private firms, and the marginal effects, larger for the latter. Specifically, a unit standard deviation rise in the cash flow ratio increases the probability of private firm being involved in innovation by 0.070%, 0.084%, and 0.092%, using the pooled Tobit, random effects Tobit, and IV Tobit estimators, respectively, compared to 0.046%, 0.051%, and 0.062% for foreign firms. In addition, a unit standard deviation rise in the cash flow ratio enhances new product sales of innovating firms by 5.846%, 6.944%, and 7.426% for private firms when using the corresponding estimators, compared to 5.639%, 6.318%, and 6.765% for foreign firms. This, again, indicates private firms are more constrained by the availability of internal finance.

[Insert Table 3.6 here]

It is interesting to note that the coefficients on the sum of cash flow are significant and positive for SOEs when using the pooled Tobit estimator and the random effects Tobit estimator. This is probably because we consider the contemporaneous cash flow effect in the augmented specification, and this variable may be endogenous. When using the IV Tobit estimator to control for endogeneity, this significance disappears. In addition, whichever the estimator used, the sum of the cash flow coefficients is not significant for collective firms. This suggests that

SOEs and collective firms are the least financially constrained, in line of our Hypothesis 2.[17]

In summary, our results confirm the presence of a "lending bias" and "political pecking order" in the Chinese capital market. Given the lower efficiency of SOEs, we believe that these firms are still subject to "soft budget constraints", and can easily obtain external funds to support their innovation activities. A similar situation applies to collective firms because of their strong relationship with local governments. However, private firms suffer more from high levels of asymmetric information and agency costs, thus they are the most restricted in their access to finance. Considering their higher productivity and more active involvement in innovation, we believe private firms are discriminated by the Chinese financial system. In terms of foreign firms, on the one hand, they face some degree of financial constraints, suggesting their innovation investment suffers from the underdevelopment of the Chinese capital market. On the other hand, their financial constraints are relatively lower than those of private firms, probably due to financial support from their parent companies.

### 3.6.3. Exploring firms' heterogeneity

Given its large size, our sample is likely to be characterized by considerable firm heterogeneity. We next investigate whether the sensitivities of new product sales to cash flow vary for different types of firms. To this end, we estimate the augmented specification of the Euler equation (Equation 3.2) for the firms classified by size, location, political affiliation, percentage of state shares, and organizational style. Our

[17] The results were robust to using interaction variables instead of dividing by sub-groups. These results are available on request.

classification criteria are described in detail in the Appendix. All results are obtained using the IV Tobit estimator and presented in Table 3.7[18].

[Insert Table 3.7 here]

With reference to size, the regression results for small firms show a positive and significant (at 1% level) sensitivity of new product sales to the cash flow coefficient. The corresponding sensitivity is only significant at the 10% level for medium-sized firms, and insignificant for large firms. The elasticity suggests that a one unit standard deviation rise in cash flow increase the probability of small firms being involved in innovation by 0.040%. For those small firms who are already involved in innovation, a one unit standard deviation rise in cash flow is associated with a 8.442% increase in new product sales. Both of these two marginal effects for small firms are larger than the corresponding ones in medium-sized and large firms. These findings provide support for Hypothesis 3a.

It is worth noting that the coefficient on lagged new product sales of small firms is greater than that of medium and large firms, indicating faster growth of innovation. This can be explained considering that small firms are becoming the most active participants in innovation in China due to high returns from new products. Even though small firms are characterized by growth and huge potential, their innovation activities are more financially constrained by the availability of their internal finance than those of larger firms. This conclusion is in line with findings in the German market (Czarnitzki and Hottenrott, 2011), the US market (Brown, Fazzari and Petersen, 2009), and the UK and European markets (Martinsson, 2010).

[18] All results were robust to estimating the baseline Euler equation model and to using a pooled or random-effects Tobit estimator.

Table 3.7 also shows regression results for different regions in China: the East (or Costal), Central Core, and West (or Hinterland). The higher value of the coefficient on lagged new product sales in the East reflects its relatively faster growth of innovation. The sum of the cash flow coefficients is positive and significant at the 1% level for the East, while it is only significant at the 5% level for the Central region, and poorly significant for the West. Moreover, the marginal effects on the sum of the cash flow terms are much greater in the East than in the Center and the West, no matter if we focus on the probability effect (whereby the marginal effects are 0.044%, 0.007%, and -0.086%, respectively, in Eastern, Central, and Western regions regions) or the quantity effect (with effects of 9.406%, 0.769%, and -4.296% in the three regions). This suggests that a rise in cash flow increases firms' new product sales by more in the coastal region. Therefore, in line with Hypothesis 3b, firms' innovation activities are more financially constrained in Eastern China than in the rest of the territory.

The effects of political affiliation effects are also explored in Table 3.7. Firms are divided into three groups: firms with no political affiliation, with medium political affiliation (i.e. affiliation at levels lower than central and provincial governments), and with high political affiliation (i.e. affiliation with central or provincial governments). We observe that the sum of the cash flow coefficients is significant for firms with no political affiliation, but poorly determined for firms with medium or high political affiliation. Therefore, in line with Hypothesis 3c, the innovation activities of firms with no political affiliation are more financially constrained by the availability of internal finance than those of their affiliated counterparts.

Focusing on state shares, the sum of the cash flow coefficients is positive and significant for firms without state ownership, and poorly determined for firms with a positive percentage of state shares. In line with Hypothesis 3c, this indicates that the innovation activities of firms without state shares are more like to suffer from financing constraints than those of firms with positive state ownership.

Finally, Table 3.7 presents estimation results for joint-venture firms and sole proprietorship firms. Joint-venture firms are defined as a collaboration or association of any two or more firms owned by different agents, undertaken for mutual profit. Sole proprietorship firms, on the other hand, are owned by a single agent. In our sample, 14.44% of joint-ventures participate in innovation activities. This ratio is larger than that of the average of the full sample (10.46%), and larger than that of sole proprietorship firms (9.20%). From the regression results, we observe that the sum of the cash flow coefficients is significantly positive for sole proprietorship firms, but poorly determined for joint-ventures, indicating the innovation activities of the former group are more constrained by the availability of internal finance. We believe many firms with innovation activities that are unable to obtain conventional financing may team up with other firms to find substitute financing. This conclusion confirms our Hypothesis 3d.

In summary, applying the IV Tobit estimator to the augmented specification of the Euler equation, we find the availability of internal finance represents a binding constraint for small firms, coastal firms, and firms who have low political affiliation and fewer state shares. Moreover, joint-ventures are less likely to face financial constraints that sole proprietorship firms. These conclusions support our Hypotheses

3a, 3b, 3c, and 3d, and indicate an imbalance of financial resources allocation in the Chinese capital market.

## 3.7. Robustness tests

### 3.7.1. Alternative measurement of innovation activities

We use the ratio of R&D expenditures to total assets as an alternative measure of innovation activities. The regression results are present in Table 3.8. Obviously, there are fewer observations because R&D expenditures in our database are only recorded over the period 2005-2007. It is interesting to note that the coefficients on the long-term debt issues are significant when the pooled and random-effects Tobit estimators are used, but not when the IV Tobit estimator is used. The coefficients on the lagged cash flow in the baseline Euler equation and the sum of the cash flow coefficients in the augmented Euler equation are all positive and significant. These results are consistent with our findings based in new product sales, indicating Chinese firms' R&D expenditures are financially constrained by the availability of internal finance.

[Insert Table 3.8 here]

### 3.7.2. Including the change of cash holdings

Brown and Petersen (2011) argue that firms most likely to face financing frictions rely extensively on cash holdings to smooth R&D expenses. Specifically, due to high adjustment costs for innovation activities, firms which undertake a non-trivial amount of innovation should be concerned about maintaining a smooth path of innovation. One way for smoothing innovation is to build and utilize precautionary cash holdings. Firms facing financial constraints may actively use cash holdings to smooth their innovation activities. If the change of cash holdings ($\Delta$*CashHoldings*) is included together with other sources of financing in the regression, it should attract a negative coefficient since reductions in cash holdings free liquidity for innovation. For firms not facing financing constraints, the coefficient on $\Delta$*CashHoldings* should be approximately zero.

Table 3.9 shows the estimates of the baseline and augmented Euler equation, which includes $\Delta$*CashHoldings* as an additional variable. Focusing on the coefficient on lagged $\Delta$*CashHoldings* in the baseline Euler equation and the sum of the $\Delta$*CashHoldings* coefficients in the augmented Euler equation, we observe that both are negative, although not all of them are significant. Additionally, the coefficients of the lagged cash flow or the sum of the cash flow coefficients are still positive and significant, indicating Chinese firms' innovation activities are financially constrained by the availability of internal financing, even after controlling for changes in cash holdings.

[Insert Table 3.9 here]

### 3.7.3. Exploring firm's heterogeneity in the private firms' sample

As private firms represent our largest group (61% of our sample), we investigate whether the sensitivities of new product sales to cash flow still vary for different types of private firms. We use the same classification schemes, the same augmented specification of the Euler equation, and the same IV Tobit estimator as in Section 3.6.3. The regression results are presented in Table 3.10 and are consistent with our previous findings. Specifically, even within the private firms sub-sample, the coefficients on cash flow are still positive and significant for small firms, coastal firms, and firms with low political affiliation, no state share, and sole proprietorship. Consistent with what we had found for the full sample, this indicates that the innovation activities of these particular types of firms are constrained by the availability of internal finance.

[Insert Table 3.10 here]

## 3.8. Conclusion

The effects of financial constraints on corporate fixed investment have been substantially discussed since Fazzari, Hubbard, and Petersen's (1988) pioneering paper, which suggested, for the first time, that the sensitivity of investment to cash flow can be seen as an indicator of the presence of financing constraints. Recently, the literature on financial constraints has been extended beyond fixed investment to analyze the impact of financial constraints on other corporate activities, such as inventory investment, employment, and export participation. Due to the crucial effect of innovation on economic growth, much attention has been paid to R&D investment in developed countries such as the US, the UK, and Europe. Only a few studies have attempted to study the impact of financial constraints in the context of China, but most of them focused on fixed investment or firm growth. Our study fills a gap in the literature testing the impact of financial constraints on Chinese firms' innovation activities.

We use a very large firm-level dataset over the period 2000−2007, which consists of 120,753 unlisted firms from 31 provinces or province-equivalent municipal cities. Based on a wide range of specification and estimation methods, we document that Chinese firms' innovation activities are subject to financial constraints. Private firms suffer the most, followed by foreign firms, while SOEs and collective firms are the least financially constrained. Moreover, the availability of internal finance represents a binding constraint for small firms, coastal firms, and firms who have low political affiliation and fewer state shares. Last, joint-ventures are less likely to face financial constraints than sole proprietorships.

These findings confirm the presence of "lending bias" and "political pecking order" in the Chinese capital market. Despite being the most active innovation participant over the period examined, private firms have been discriminated against by the Chinese capital market. As for foreign firms, their innovation activities have also been constrained by the imperfection and underdevelopment of the Chinese capital. By contrast, thanks to the support these firms get from state banks and local governments, SOEs and collective firms' innovation activities are not constrained by the availability of internal finance.

Our research complements "The National Medium- and Long-Term Program of Science and Technology Development (2006-2020)". Specifically, our findings suggest that policies should be established to alleviate financing obstacles to support the development of innovation activities in small private firms, coastal firms, and firms with low political affiliation, fewer state shares, and sole proprietorship. To this end, non-banking financial institutions, such as securities, insurance, trust and finance companies, could be set up.

Further research needs to be undertaken in the following directions. First, as our regressions are only based on the Euler equation model, it would be interesting to test whether the results are robust to using other models, such as the error-correction model (Bond et al., 2003; Guariglia, 2008). Second, one could test whether the results also hold for listed firms. Third, it would be interesting to investigate whether similar results apply in other developing countries.

**Table 3.1: Distribution of the innovation participation rate (measured as the percentage of observations with positive new product sales) by year, industry and ownership type**

| | *Full sample* | *SOEs* | *Foreign* | *Private* | *Collective* |
|---|---|---|---|---|---|
| ***Year*** | | | | | |
| 2000 | 10.08 | 16.14 | 6.12 | 10.78 | 5.43 |
| 2001 | 9.25 | 15.45 | 6.73 | 9.30 | 5.50 |
| 2002 | 8.60 | 15.18 | 5.10 | 8.99 | 4.70 |
| 2003 | 7.86 | 14.30 | 5.05 | 8.10 | 4.14 |
| 2005 | 11.37 | 16.78 | 7.76 | 11.99 | 7.66 |
| 2006 | 12.33 | 16.88 | 8.08 | 13.44 | 7.35 |
| 2007 | 12.19 | 17.73 | 8.80 | 13.29 | 5.19 |
| ***Industry*** | | | | | |
| Metal & metal products | 7.67 | 18.03 | 5.59 | 7.65 | 4.01 |
| Nonmetal products & petroleum processing | 6.71 | 6.62 | 7.51 | 6.97 | 3.85 |
| Chemicals & plastic | 11.90 | 20.10 | 7.38 | 12.81 | 6.51 |
| Machinery & Equipment | 17.09 | 29.24 | 11.65 | 17.13 | 8.58 |
| Electrical equipment | 16.35 | 37.11 | 9.95 | 18.27 | 11.37 |
| Transport equipment | 18.18 | 26.52 | 10.93 | 19.40 | 5.96 |
| Food & tobacco | 9.56 | 12.28 | 7.69 | 9.67 | 7.53 |
| Textile | 6.03 | 18.67 | 3.20 | 6.69 | 4.66 |
| Leather & timber & furniture | 5.11 | 3.61 | 3.53 | 6.00 | 3.67 |
| Mining & Logging | 3.76 | 2.69 | 4.64 | 4.23 | 2.13 |
| **Average** | 10.26 | 15.91 | 6.85 | 10.94 | 5.68 |

*Notes*: The innovation participation rate is calculated as the percentage of observations with positive new products. The ownership classification is based on the majority average ownership shares (at least 50%). The year 2004 is missing because the variable of new products is not available in that year.

## Table 3.2: Sample means and medians (in parentheses)

| | *Full sample* | *New products =0* | *New products >0* | *Diff* |
|---|---|---|---|---|
| **Main regression variables** | | | | |
| New products/Total assets | 4.56<br>(0.00) | 0.00<br>(0.00) | 44.47<br>(0.00) | 0.00 |
| Sales/Total assets | 162.44<br>(118.47) | 166.44<br>(55.92) | 124.39<br>(111.67) | 0.00 |
| Cash flow/Total assets | 8.17<br>(5.61) | 8.29<br>(2.46) | 7.60<br>(6.60) | 0.00 |
| New long-term debt/Total assets | 0.04<br>(0.00) | 0.01<br>(0.00) | 0.04<br>(0.00) | 0.24 |
| **General firm characteristics** | | | | |
| Assets | 112.83<br>(19.83) | 80.96<br>(32.87) | 410.51<br>(35.16) | 0.00 |
| Age | 11.48<br>(8.00) | 10.98<br>(30.00) | 16.88<br>(8.00) | 0.00 |
| Sale growth | 12.23<br>(10.78) | 12.11<br>(6.14) | 14.48<br>(10.54) | 0.00 |
| Assets growth | 9.81<br>(4.78) | 10.09<br>(-0.16) | 11.02<br>(4.98) | 0.00 |
| Employee growth | 1.85<br>(0.00) | 1.71<br>(-1.31) | 2.16<br>(0.67) | 0.00 |
| Labor productivity | 313.74<br>(167.15) | 308.66<br>(77.42) | 372.74<br>(202.53) | 0.00 |
| Wage per employee | 13.73<br>(10.69) | 13.53<br>(8.92) | 16.66<br>(14.78) | 0.00 |
| **Financial variables** | | | | |
| Leverage | 57.94<br>(58.94) | 57.73<br>(66.51) | 58.63<br>(47.38) | 0.00 |
| Liquidity | 5.82<br>(6.22) | 5.89<br>(-2.40) | 6.49<br>(15.65) | 0.00 |
| Coverage | 12.00<br>(2.81) | 11.90<br>(1.10) | 12.21<br>(3.10) | 0.94 |
| **China-specific variables** | | | | |
| Region | 1.36<br>(1.00) | 1.35<br>(2.00) | 1.47<br>(1.00) | 0.00 |
| Percentage of state shares | 9.29<br>(0.00) | 8.73<br>(100.00) | 15.14<br>(0.00) | 0.00 |
| Political affiliation | 71.63<br>(90.00) | 71.98<br>(40.00) | 61.43<br>(90.00) | 0.00 |
| Observation | 745,548 | 571,303 | 65,339 | |

Notes: Assets are expressed in millions of yuan. All other variables except age, region and political affiliation are expressed in percentage terms. All variables were deflated using provincial ex-factory producer price indices. The last column (*Diff*) presents *p*-values from an independent samples mean-equality test between the positive new products group and the no new products group. See Appendix for complete definitions of all variables.

## Table 3.3: Sample means and medians (in parentheses)

| | *SOEs* | *Foreign* | *Private* | *Collective* | *Diff1* | *Diff2* | *Diff3* |
|---|---|---|---|---|---|---|---|
| **Main regression variables** | | | | | | | |
| New products/Total assets | 3.20<br>(0.00) | 3.77<br>(0.00) | 5.26<br>(0.000) | 2.16<br>(0.00) | 0.00 | 0.00 | 0.00 |
| Sales/Total assets | 81.22<br>(55.92) | 143.96<br>(111.67) | 179.26<br>(132.43) | 167.68<br>(117.93) | 0.00 | 0.00 | 0.00 |
| Cash flow/Total assets | 3.84<br>(2.46) | 8.71<br>(6.60) | 8.50<br>(5.77) | 8.85<br>(5.67) | 0.00 | 0.00 | 0.00 |
| New long-term debt/Total assets | -0.13<br>(0.00) | -0.04<br>(0.00) | 0.11<br>(0.00) | -0.09<br>(0.00) | 0.00 | 0.00 | 0.00 |
| **General firm characteristics** | | | | | | | |
| Assets | 392.56<br>(32.87) | 128.37<br>(35.16) | 75.99<br>(16.31) | 43.85<br>(16.11) | 0.00 | 0.00 | 0.00 |
| Age | 28.61<br>(30.00) | 8.24<br>(8.00) | 9.66<br>(7.00) | 16.58<br>(13.00) | 0.00 | 0.00 | 0.00 |
| Sale growth | 8.25<br>(6.14) | 11.71<br>(10.54) | 13.75<br>(12.16) | 7.83<br>(7.73) | 0.00 | 0.00 | 0.00 |
| Assets growth | 1.78<br>(-0.16) | 8.61<br>(4.98) | 12.11<br>(6.64) | 6.16<br>(1.90) | 0.00 | 0.00 | 0.00 |
| Employee growth | -4.82<br>(-1.31) | 5.04<br>(0.67) | 2.42<br>(0.00) | -1.45<br>(0.00) | 0.00 | 0.00 | 0.00 |
| Labor productivity | 179.10<br>(77.42) | 429.11<br>(202.53) | 298.32<br>(173.83) | 258.57<br>(140.90) | 0.00 | 0.00 | 0.00 |
| Wage per employee | 11.86<br>(8.92) | 19.91<br>(14.78) | 12.41<br>(10.23) | 10.79<br>(9.11) | 0.00 | 0.24 | 0.00 |
| **Financial variables** | | | | | | | |
| Leverage | 68.42<br>(66.51) | 47.73<br>(47.38) | 59.24<br>(61.00) | 60.74<br>(61.10) | 0.00 | 0.00 | 0.00 |
| Liquidity | -5.91<br>(-2.40) | 15.52<br>(15.65) | 4.20<br>(4.43) | 7.10<br>(7.87) | 0.00 | 0.00 | 0.00 |
| Coverage | 0.93<br>(1.10) | 27.46<br>(3.10) | 10.59<br>(3.12) | 5.82<br>(2.54) | 0.01 | 0.00 | 0.00 |
| **China-specific variables** | | | | | | | |
| Region | 1.83<br>(2.00) | 1.08<br>(1.00) | 1.38<br>(1.00) | 1.42<br>(1.00) | 0.00 | 0.00 | 0.00 |
| Percentage of state shares | 87.26<br>(100.00) | 1.41<br>(0.00) | 1.99<br>(0.00) | 1.21<br>(0.00) | 0.00 | 0.00 | 0.00 |
| Political affiliation | 37.81<br>(40.00) | 78.69<br>(90.00) | 75.75<br>(90.00) | 63.81<br>(63.00) | 0.00 | 0.00 | 0.00 |
| Observation | 59,922 | 138,356 | 457,715 | 59,982 | | | |

Notes: Assets are expressed in millions of yuan. All other variables except age, region and political affiliation are expressed in percentage terms. All variables were deflated using provincial ex-factory producer price indices. The last three columns present *p*-values from an independent samples mean-equality test between the SOEs group and the foreign group (*Diff1*); between the SOEs group and the private group (*Diff2*); and between the foreign group and the private group (*Diff3*). See Appendix for complete definitions of all variables.

## Table 3.4: Baseline and augmented Euler equation for the full sample

| | *Baseline Euler Equation* | | | *Augmented Euler Equation* | | |
|---|---|---|---|---|---|---|
| | *Pooled Tobit* | *Random effects Tobit* | *IV Tobit* | *Pooled Tobit* | *Random effecst Tobit* | *IV Tobit* |
| $npa_{t-1}$ | 2.608$^{***}$ | 2.060$^{***}$ | 2.584$^{***}$ | 2.603$^{***}$ | 2.151$^{***}$ | 2.570$^{***}$ |
| | (0.023) | (0.017) | (0.016) | (0.023) | (0.017) | (0.017) |
| $npa_{t-1}^2$ | -0.006$^{***}$ | -0.005$^{***}$ | -0.006$^{***}$ | -0.006$^{***}$ | -0.005$^{***}$ | -0.006$^{***}$ |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $sa$ | | | | 0.023$^{***}$ | 0.031$^{***}$ | -0.198$^{***}$ |
| | | | | (0.004) | (0.003) | (0.025) |
| $sa_{t-1}$ | -0.072$^{***}$ | -0.065$^{***}$ | -0.081$^{***}$ | -0.094$^{***}$ | -0.093$^{***}$ | 0.102$^{***}$ |
| | (0.003) | (0.003) | (0.003) | (0.005) | (0.004) | (0.022) |
| $cfa_t$ | | | | 0.136$^{***}$ | 0.169$^{***}$ | 0.468$^{**}$ |
| | | | | (0.037) | (0.035) | (0.230) |
| $cfa_{t-1}$ | 0.077$^{**}$ | 0.140$^{***}$ | 0.231$^{***}$ | -0.013 | 0.040 | -0.127 |
| | (0.032) | (0.031) | (0.053) | (0.039) | (0.037) | (0.152) |
| | [0.016] | [0.027] | [0.050] | | | |
| | {1.316} | {2.295} | {4.068} | | | |
| $dbta_t$ | | | | 0.066 | 0.066 | -0.218 |
| | | | | (0.041) | (0.040) | (0.670) |
| $dbta_{t-1}$ | 0.010 | 0.016 | -0.111 | 0.018 | 0.027 | -0.042 |
| | (0.038) | (0.038) | (0.240) | (0.039) | (0.039) | (0.117) |
| sum(cfa) | | | | 0.123$^{***}$ | 0.209$^{***}$ | 0.340$^{***}$ |
| | | | | (0.035) | (0.035) | (0.088) |
| | | | | [0.025] | [0.041] | [0.056] |
| | | | | {2.099} | {3.441} | {4.732} |
| sum(dbta) | | | | 0.084 | 0.093 | -0.260 |
| | | | | (0.062) | (0.061) | (0.778) |
| Pseudo $R^2$ | 0.132 | | | 0.132 | | |
| Rho | | 0.384 | | | 0.387 | |
| Wald test of exogeneity | | | 67.45 | | | 86.03 |
| ($p$-value) | | | (0.000) | | | (0.000) |
| Observations | | | | | | |
| Left-censored | 263,273 | 263,273 | 188,779 | 263,273 | 263,273 | 188,779 |
| Uncensored | 33,923 | 33,923 | 26,296 | 33,923 | 33,923 | 26,296 |

Notes: The dependent variable npa (new products/total assets) is a censored variable which takes its real value if the firm has positive new products output (uncensored observations), and zero otherwise (left-censored observations). Outliers in all regression variables are trimmed at the 1% and 99% level. We estimate the baseline and augmented Euler equations using the pooled Tobit, random effects Tobit and IV Tobit estimators. Heteroskedasticity-consistent standard errors are reported in parentheses. $^{***}$, $^{**}$ and $^{*}$ indicate significance at 1%, 5% and 10% level respectively. Time dummies, industry dummies and time-industry interaction terms are included in all specifications but not reported in this results table. Pseudo $R^2$ is McFadden's pseudo R-squared in pooled Tobit regression. Rho is the percent contribution to the total variance of the panel-level variance component in random effects Tobit regression. We instrument sales and all financing variables using their own values lagged twice (t-2) in the IV Tobit regression. *P*-values of the Wald test of exogeneity are shown in parentheses. The numbers in square brackets are marginal effects on the probability of being uncensored, and in curly brackets are marginal effects on uncensored observations. See Appendix for complete definitions of all variables.

## Table 3.5: Baseline Euler equation differentiating firms on the basis of ownership

| | *Pooled Tobit* | | | | *Random effects Tobit* | | | | *IV Tobit* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *SOEs* | *Foreign* | *Private* | *Collective* | *SOEs* | *Foreign* | *Private* | *Collective* | *SOEs* | *Foreign* | *Private* | *Collective* |
| $npa_{t-1}$ | 1.722$^{***}$ | 3.002$^{***}$ | 2.576$^{***}$ | 3.050$^{***}$ | 1.452$^{***}$ | 2.418$^{***}$ | 2.182$^{***}$ | 2.596$^{***}$ | 1.673$^{***}$ | 3.001$^{***}$ | 2.528$^{***}$ | 2.945$^{***}$ |
| | (0.053) | (0.067) | (0.027) | (0.115) | (0.030) | (0.054) | (0.021) | (0.083) | (0.029) | (0.055) | (0.020) | (0.088) |
| $npa_{t-1}^2$ | -0.003$^{***}$ | -0.008$^{***}$ | -0.006$^{***}$ | -0.008$^{***}$ | -0.003$^{***}$ | -0.006$^{***}$ | -0.005$^{***}$ | -0.007$^{***}$ | -0.003$^{***}$ | -0.008$^{***}$ | -0.006$^{***}$ | -0.007$^{***}$ |
| | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $sa_{t-1}$ | -0.045$^{***}$ | -0.045$^{***}$ | -0.085$^{***}$ | -0.050$^{***}$ | -0.036$^{***}$ | -0.036$^{***}$ | -0.080$^{***}$ | -0.040$^{***}$ | -0.062$^{***}$ | -0.058$^{***}$ | -0.097$^{***}$ | -0.067$^{***}$ |
| | (0.006) | (0.009) | (0.003) | (0.011) | (0.006) | (0.009) | (0.003) | (0.010) | (0.008) | (0.012) | (0.004) | (0.014) |
| $cfa_{t-1}$ | 0.082 | 0.209$^{**}$ | 0.270$^{***}$ | -0.132 | 0.066 | 0.208$^{**}$ | 0.326$^{***}$ | -0.049 | 0.300 | 0.629$^{***}$ | 0.487$^{***}$ | 0.105 |
| | (0.060) | (0.086) | (0.042) | (0.134) | (0.054) | (0.089) | (0.041) | (0.133) | (0.194) | (0.162) | (0.070) | (0.216) |
| | [0.052] | [0.025] | [0.057] | [-0.016] | [0.038] | [0.024] | [0.067] | [-0.006] | [0.047] | [0.028] | [0.045] | [0.012] |
| | {1.586} | {3.063} | {4.808} | {-1.756} | {1.225} | {2.492} | {5.604} | {-0.639} | {1.405} | {3.156} | {5.774} | {0.943} |
| $dbta_{t-1}$ | 0.045 | -0.085 | 0.006 | 0.056 | 0.028 | -0.016 | 0.014 | 0.058 | -0.727 | 0.960 | 0.110 | -1.185 |
| | (0.041) | (0.181) | (0.045) | (0.210) | (0.045) | (0.167) | (0.047) | (0.175) | (0.548) | (1.491) | (0.264) | (0.985) |
| Pseudo $R^2$ | 0.190 | 0.136 | 0.128 | 0.148 | | | | | | | | |
| Rho | | | | | 0.406 | 0.399 | 0.346 | 0.398 | | | | |
| Wald test of exogeneity | | | | | | | | | 21.70 | 11.71 | 59.55 | 11.25 |
| (*p*-value) | | | | | | | | | (0.000) | (0.008) | (0.000) | (0.011) |
| Observations | | | | | | | | | | | | |
| Left-censored | 19,695 | 53,417 | 157,133 | 22,514 | 19,695 | 53,417 | 157,133 | 22,514 | 12,693 | 38,949 | 114,824 | 15,104 |
| Uncensored | 3,854 | 4,207 | 22,768 | 1,338 | 3,854 | 4,207 | 22,768 | 1,338 | 2,633 | 3,362 | 18,090 | 962 |

Notes: The dependent variable npa (new products/total assets) is a censored variable which takes its real value if the firm has positive new products output (uncensored observations), and zero otherwise (left-censored observations). Ownership groups are classified based on the majority average ownership shares. Outliers in all regression variables are trimmed at the 1% and 99% level. We estimate the baseline Euler equation using the pooled Tobit, random effects Tobit and IV Tobit estimators. Heteroskedasticity-consistent standard errors are reported in parentheses. $^{***}$, $^{**}$ and $^{*}$ indicate significance at 1%, 5% and 10% level respectively. Time dummies, industry dummies and time-industry interaction terms are included in all specifications but not reported in this results table. Pseudo $R^2$ is McFadden's pseudo R-squared in pooled Tobit regression. Rho is the percent contribution to the total variance of the panel-level variance component in random effects Tobit regression. We instrument sales and all financing variables using their own values lagged twice (t-2) in the IV Tobit regression. *P*-values of the Wald test of exogeneity are shown in parentheses. The numbers in square brackets are marginal effects on the probability of being uncensored, and in curly brackets are marginal effects on uncensored observations. See Appendix for complete definitions of all variables and criteria of all classifications.

### Table 3.6: Augmented Euler equation differentiating firms on the basis of ownership

| | Pooled Tobit | | | | Random effects Tobit | | | | IV Tobit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *SOEs* | *Foreign* | *Private* | *Collective* | *SOEs* | *Foreign* | *Private* | *Collective* | *SOEs* | *Foreign* | *Private* | *Collective* |
| $npa_{t-1}$ | 1.717*** | 2.991*** | 2.570*** | 3.049*** | 1.434*** | 2.403*** | 2.172*** | 2.592*** | 1.634*** | 2.977*** | 2.505*** | 2.939*** |
| | (0.052) | (0.067) | (0.027) | (0.114) | (0.030) | (0.054) | (0.021) | (0.083) | (0.118) | (0.056) | (0.021) | (0.097) |
| $npa_{t-1}^2$ | -0.003*** | -0.007*** | -0.006*** | -0.008*** | -0.003*** | -0.006*** | -0.005*** | -0.007*** | -0.003*** | -0.008*** | -0.006*** | -0.007*** |
| | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) | (0.000) |
| *sa* | 0.020* | 0.018 | 0.024*** | 0.009 | 0.029*** | 0.029** | 0.031*** | 0.014 | -0.209 | -0.126 | -0.234*** | -0.285*** |
| | (0.012) | (0.013) | (0.005) | (0.015) | (0.006) | (0.012) | (0.004) | (0.014) | (0.429) | (0.077) | (0.032) | (0.104) |
| $sa_{t-1}$ | -0.067*** | -0.062*** | -0.108*** | -0.058*** | -0.065*** | -0.062*** | -0.108*** | -0.051*** | 0.121 | 0.048 | 0.117*** | 0.211** |
| | (0.014) | (0.015) | (0.006) | (0.018) | (0.008) | (0.013) | (0.005) | (0.015) | (0.407) | (0.064) | (0.027) | (0.092) |
| *sum(cfa)* | 0.150** | 0.385*** | 0.328*** | -0.157 | 0.162*** | 0.446*** | 0.404*** | -0.075 | 0.935 | 1.004*** | 0.719*** | -0.167 |
| | (0.065) | (0.097) | (0.046) | (0.147) | (0.060) | (0.101) | (0.045) | (0.146) | (1.100) | (0.322) | (0.114) | (0.349) |
| | [0.096] | [0.046] | [0.070] | [-0.019] | [0.095] | [0.051] | [0.084] | [-0.009] | [0.083] | [0.062] | [0.092] | [-0.076] |
| | {2.915} | {5.639} | {5.846} | {-2.087} | {3.016} | {6.318} | {6.944} | {-0.980} | {2.647} | {6.765} | {7.426} | {-1.249} |
| *sum(dbta)* | 0.064 | -0.285 | 0.097 | 0.127 | 0.020 | -0.272 | 0.132* | 0.078 | -1.290 | 4.581 | 0.521 | -5.427* |
| | (0.058) | (0.264) | (0.075) | (0.299) | (0.071) | (0.263) | (0.076) | (0.283) | (6.206) | (4.977) | (0.835) | (3.149) |
| Pseudo $R^2$ | 0.190 | 0.136 | 0.128 | 0.148 | | | | | | | | |
| Rho | | | | | 0.420 | 0.402 | 0.349 | 0.398 | | | | |
| Wald test of exogeneity | | | | | | | | | 26.05 | 8.75 | 73.02 | 12.04 |
| (*p*-value) | | | | | | | | | (0.000) | (0.033) | (0.000) | (0.007) |
| Observations | | | | | | | | | | | | |
| Left-censored | 19,695 | 53,417 | 157,133 | 22,514 | 19,695 | 53,417 | 157,133 | 22,514 | 12,693 | 38,949 | 114,824 | 15,104 |
| Uncensored | 3,854 | 4,207 | 22,768 | 1,338 | 3,854 | 4,207 | 22,768 | 1,338 | 2,633 | 3,362 | 18,090 | 962 |

Notes: The dependent variable npa (new products/total assets) is a censored variable which takes its real value if the firm has positive new products output (uncensored observations), and zero otherwise (left-censored observations). Ownership groups are classified based on the majority average ownership shares. Outliers in all regression variables are trimmed at the 1% and 99% level. We estimate the augmented Euler equation using the pooled Tobit, random effects Tobit and IV Tobit estimators. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% level respectively. Time dummies, industry dummies and time-industry interaction terms are included in all specifications but not reported in this results table. Pseudo $R^2$ is McFadden's pseudo R-squared in pooled Tobit regression. Rho is the percent contribution to the total variance of the panel-level variance component in random effects Tobit regression. We instrument sales and all financing variables using their own values lagged twice (t-2) in the IV Tobit regression. *P*-values of the Wald test of exogeneity are shown in parentheses. The numbers in square brackets are marginal effects on the probability of being uncensored, and in curly brackets are marginal effects on uncensored observations. See Appendix for complete definitions of all variables and criteria of all classifications.

**Table 3.7: Augmented Euler equation estimated using the IV Tobit estimator: differentiating firms on the basis of size, region, political affiliation, percentage of state shares, and organization style in the full sample**

| | *Size* | | | *Region* | | | *Political Affiliation* | | | *State shares* | | *Organization style* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Small* | *Medium* | *Large* | *East* | *Central* | *West* | *No* | *Medium* | *High* | *No* | *Yes* | *SP* | *JV* |
| $npa_{t-1}$ | 3.563$^{***}$ | 2.818$^{***}$ | 1.837$^{***}$ | 2.594$^{***}$ | 2.196$^{***}$ | 2.491$^{***}$ | 2.755$^{***}$ | 2.403$^{***}$ | 1.590$^{***}$ | 2.750$^{***}$ | 1.864$^{***}$ | 2.617$^{***}$ | 2.205$^{***}$ |
| | (0.084) | (0.030) | (0.016) | (0.021) | (0.042) | (0.048) | (0.026) | (0.028) | (0.025) | (0.022) | (0.021) | (0.021) | (0.028) |
| $npa_{t-1}^2$ | -0.009$^{***}$ | -0.007$^{***}$ | -0.004$^{***}$ | -0.006$^{***}$ | -0.005$^{***}$ | -0.007$^{***}$ | -0.007$^{***}$ | -0.006$^{***}$ | -0.003$^{***}$ | -0.007$^{***}$ | -0.004$^{***}$ | -0.007$^{***}$ | -0.005$^{***}$ |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $sa$ | -0.228$^{**}$ | -0.067 | -0.001 | -0.224$^{***}$ | -0.115$^{**}$ | -0.032 | -0.163$^{***}$ | -0.247$^{***}$ | -0.138$^{**}$ | -0.174$^{***}$ | -0.234$^{***}$ | -0.198$^{***}$ | -0.120$^{**}$ |
| | (0.098) | (0.044) | (0.034) | (0.032) | (0.052) | (0.074) | (0.036) | (0.045) | (0.064) | (0.032) | (0.038) | (0.029) | (0.053) |
| $sa_{t-1}$ | 0.098 | 0.018 | -0.014 | 0.093$^{***}$ | 0.055 | 0.012 | 0.055$^{*}$ | 0.151$^{***}$ | 0.082 | 0.067$^{**}$ | 0.163$^{***}$ | 0.093$^{***}$ | 0.044 |
| | (0.080) | (0.037) | (0.029) | (0.027) | (0.044) | (0.068) | (0.030) | (0.040) | (0.057) | (0.027) | (0.034) | (0.025) | (0.047) |
| *sum(cfa)* | 2.066$^{***}$ | 0.292$^{*}$ | -0.032 | 0.972$^{***}$ | 0.333$^{**}$ | -0.162 | 1.119$^{***}$ | 0.123 | 0.046 | 0.861$^{***}$ | -0.018 | 0.641$^{***}$ | 0.257 |
| | (0.337) | (0.166) | (0.108) | (0.117) | (0.156) | (0.284) | (0.139) | (0.140) | (0.132) | (0.118) | (0.115) | (0.107) | (0.171) |
| | [0.040] | [0.006] | [-0.099] | [0.044] | [0.007] | [-0.086] | [0.044] | [0.013] | [0.033] | [0.040] | [-0.002] | [0.029] | [0.021] |
| | {8.442} | {0.654} | {-4.987} | {9.406} | {0.769} | {-4.296} | {4.983} | {1.049} | {0.113} | {4.104} | {-0.070} | {3.005} | {1.408} |
| *sum(dbta)* | -3.405 | 1.277 | 0.245 | -0.033 | 0.932 | -2.289 | -0.705 | -0.018 | 0.800 | -0.525 | 0.157 | 0.030 | 0.104 |
| | (2.724) | (1.282) | (0.958) | (1.043) | (1.261) | (1.704) | (1.070) | (1.301) | (1.715) | (0.969) | (1.050) | (0.867) | (1.808) |
| Wald test of exogeneity | 18.06 | 8.12 | 4.30 | 77.26 | 10.96 | 12.73 | 42.72 | 42.90 | 8.76 | 47.24 | 57.20 | 61.54 | 10.84 |
| ($p$-value) | (0.000) | (0.044) | (0.231) | (0.000) | (0.012) | (0.005) | (0.000) | (0.000) | (0.033) | (0.000) | (0.000) | (0.000) | (0.013) |
| Observations | | | | | | | | | | | | | |
| Left-censored | 45,559 | 97,629 | 45,584 | 144,688 | 24,881 | 19,203 | 118,363 | 60,956 | 9,453 | 156,182 | 32,590 | 155,611 | 32,699 |
| Uncensored | 2,696 | 10,182 | 13,413 | 18,694 | 3,878 | 3,719 | 14,452 | 8,124 | 3,715 | 18,511 | 7,780 | 19,588 | 6,655 |

Notes: The dependent variable npa (new products/total assets) is a censored variable which takes its real value if the firm has positive new products output (uncensored observations), and zero otherwise (left-censored observations). Outliers in all regression variables are trimmed at the 1% and 99% level. We estimate the augmented Euler equation using the IV Tobit estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. $^{***}$, $^{**}$ and $^{*}$ indicate significance at 1%, 5% and 10% level respectively. Time dummies, industry dummies and time-industry interaction terms are included in all specifications but not reported in this results table. We instrument sales and all financing variables using their own values lagged twice (t-2) in the IV Tobit regression. *P*-values of the Wald test of exogeneity are shown in parentheses. The numbers in square brackets are marginal effects on the probability of being uncensored, and in curly brackets are marginal effects on uncensored observations. See Appendix for complete definitions of all variables and classification criteria.

**Table 3.8: Robustness test on the full sample: using an alternative measurement of innovation activities (i.e. *R&D expenditures/total assets*, labeled as *rda*)**

| | *Baseline Euler Equation* | | | *Augmented Euler Equation* | | |
|---|---|---|---|---|---|---|
| | *Pooled Tobit* | *Random effects Tobit* | *IV-Tobit* | *Pooled Tobit* | *Random effects Tobit* | *IV-Tobit* |
| $rda_{t-1}$ | 2.196*** | 1.968*** | 2.178*** | 2.189*** | 1.960*** | 2.150*** |
| | (0.027) | (0.019) | (0.017) | (0.027) | (0.019) | (0.018) |
| $rda_{t-1}^2$ | -0.151*** | -0.142*** | -0.150*** | -0.150*** | -0.141*** | -0.148*** |
| | (0.005) | (0.002) | (0.002) | (0.005) | (0.002) | (0.002) |
| $sa$ | | | | -0.001*** | -0.001*** | -0.009*** |
| | | | | (0.000) | (0.000) | (0.001) |
| $sa_{t-1}$ | -0.003*** | -0.003*** | -0.003*** | -0.002*** | -0.002*** | 0.005*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) |
| $cfa_t$ | | | | 0.013*** | 0.014*** | 0.052*** |
| | | | | (0.001) | (0.001) | (0.008) |
| $cfa_{t-1}$ | 0.014*** | 0.016*** | 0.025*** | 0.006*** | 0.007*** | -0.017*** |
| | (0.001) | (0.001) | (0.002) | (0.001) | (0.001) | (0.005) |
| | [0.181] | [0.124] | [0.179] | | | |
| | {0.424} | {0.294} | {0.458} | | | |
| $dbta_t$ | | | | 0.008*** | 0.008*** | -0.051** |
| | | | | (0.002) | (0.002) | (0.023) |
| $dbta_{t-1}$ | 0.005*** | 0.004*** | -0.014* | 0.006*** | 0.006*** | -0.003 |
| | (0.002) | (0.002) | (0.008) | (0.002) | (0.002) | (0.004) |
| *sum(cfa)* | | | | 0.019*** | 0.021*** | 0.035*** |
| | | | | (0.001) | (0.001) | (0.003) |
| | | | | [0.155] | [0.169] | [0.177] |
| | | | | {0.363} | {0.402} | {0.473} |
| *sum(dbta)* | | | | 0.014*** | 0.014*** | -0.054** |
| | | | | (0.002) | (0.003) | (0.027) |
| Pseudo $R^2$ | 0.171 | | | 0.171 | | |
| Rho | | 0.293 | | | 0.294 | |
| Wald test of exogeneity | | | 156.11 | | | 130.34 |
| (p-value) | | | (0.000) | | | (0.000) |
| Observations | | | | | | |
| Left-censored | 150,097 | 150,097 | 140,374 | 150,097 | 150,097 | 140,374 |
| Uncensored | 28,193 | 28,193 | 26,841 | 28,193 | 28,193 | 26,841 |

Notes: The dependent variable rda (R&D expenditures/total assets) is a censored variable which takes its real value if the firm has positive R&D expenditures (uncensored observations), and zero otherwise (left-censored observations). There are fewer observations because the data for R&D expenditures is only available from 2005 to 2007. Outliers in all regression variables are trimmed at the 1% and 99% level. We estimate the baseline and augmented Euler equations using the pooled Tobit, random effects Tobit and IV Tobit estimators. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% level respectively. Time dummies, industry dummies and time-industry interaction terms are included in all specifications but not reported in this results table. Pseudo $R^2$ is McFadden's pseudo R-squared in pooled Tobit regression. Rho is the percent contribution to the total variance of the panel-level variance component in random effects Tobit regression. We instrument sales and all financing variables using their own values lagged twice (t-2) in the IV Tobit regression. *P*-values of the Wald test of exogeneity are shown in parentheses. The numbers in square brackets are marginal effects on the probability of being uncensored, and in curly brackets are marginal effects on uncensored observations. See Appendix for complete definitions of all variables.

**Table 3.9: Robustness test on the full sample: including the change of cash holdings (i.e. Δ*cash holdings/total assets*, labeled as Δ*cha*)**

| | *Baseline Euler Equation* | | | *Augmented Euler Equation* | | |
|---|---|---|---|---|---|---|
| | *Pooled Tobit* | *Random effects Tobit* | *IV-Tobit* | *Pooled Tobit* | *Random effects Tobit* | *IV-Tobit* |
| $npa_{t-1}$ | 2.604*** | 2.163*** | 2.583*** | 2.599*** | 2.513*** | 2.569*** |
| | (0.023) | (0.017) | (0.017) | (0.023) | (0.017) | (0.017) |
| $npa_{t-1}^2$ | -0.006*** | -0.005*** | -0.006*** | -0.006*** | -0.005*** | -0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Sa* | | | | 0.023*** | 0.031*** | -0.217*** |
| | | | | (0.004) | (0.003) | (0.026) |
| $sa_{t-1}$ | -0.072*** | -0.065*** | -0.082*** | -0.094*** | -0.093*** | 0.119*** |
| | (0.003) | (0.003) | (0.003) | (0.005) | (0.004) | (0.022) |
| $cfa_t$ | | | | 0.144*** | 0.178*** | 0.468** |
| | | | | (0.037) | (0.036) | (0.234) |
| $cfa_{t-1}$ | 0.082** | 0.146*** | 0.232*** | -0.013 | 0.043 | -0.122 |
| | (0.032) | (0.032) | (0.054) | (0.039) | (0.038) | (0.155) |
| | [0.017] | [0.029] | [0.051] | | | |
| | {1.411} | {2.412} | {4.071} | | | |
| $dbta_t$ | | | | 0.077 | 0.073* | -0.161 |
| | | | | (0.042) | (0.041) | (0.667) |
| $dbta_{t-1}$ | -0.003 | 0.002 | -0.089 | 0.007 | 0.014 | -0.032 |
| | (0.038) | (0.039) | (0.241) | (0.039) | (0.040) | (0.117) |
| $\Delta cha_t$ | | | | -0.033* | -0.035** | -0.150 |
| | | | | (0.017) | (0.017) | (0.099) |
| $\Delta cha_{t-1}$ | -0.008 | -0.014 | -0.057 | -0.022 | -0.031* | -0.034 |
| | (0.016) | (0.016) | (0.050) | (0.017) | (0.017) | (0.039) |
| *sum(cfa)* | | | | 0.132*** | 0.221*** | 0.346*** |
| | | | | (0.035) | (0.035) | (0.089) |
| | | | | [0.028] | [0.044] | [0.058] |
| | | | | {2.256} | {3.651} | {4.735} |
| *sum(dbta)* | | | | 0.084 | 0.087 | -0.193 |
| | | | | (0.063) | (0.064) | (0.776) |
| *sum(Δcha)* | | | | -0.056** | -0.067** | -0.184 |
| | | | | (0.028) | (0.028) | (0.135) |
| Pseudo $R^2$ | 0.133 | | | 0.133 | | |
| Rho | | 0.384 | | | 0.387 | |
| Wald test of exogeneity | | | 76.33 | | | 95.45 |
| (p-value) | | | (0.000) | | | (0.000) |
| Observations | | | | | | |
| Left-censored | 256,376 | 256,376 | 184,482 | 256,376 | 256,376 | 184,482 |
| Uncensored | 33,337 | 33,337 | 25,867 | 33,337 | 33,337 | 25,867 |

Notes: The dependent variable npa (new products/total assets) is a censored variable which takes its real value if the firm has positive new products output (uncensored observations), and zero otherwise (left-censored observations). Outliers in all regression variables are trimmed at the 1% and 99% level. We estimate the baseline and augmented Euler equations using the pooled Tobit, random effects Tobit and IV Tobit estimators. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% level respectively. Time dummies, industry dummies and time-industry interaction terms are included in all specifications but not reported in this results table. Pseudo $R^2$ is McFadden's pseudo R-squared in pooled Tobit regression. Rho is the percent contribution to the total variance of the panel-level variance component in random effects Tobit regression. We instrument sales and all financing variables using their own values lagged twice (t-2) in the IV Tobit regression. *P*-values of the Wald test of exogeneity are shown in parentheses. The numbers in square brackets are marginal effects on the probability of being uncensored, and in curly brackets are marginal effects on uncensored observations. See Appendix for complete definitions of all variables.

**Table 3.10: Robustness test based on the private firms' sample: differentiating firms on the basis of size, region, political affiliation, percentage of state shares, and organization style**

| | *Size* | | | *Region* | | | *Political Affiliation* | | | *State Shares* | | *Organization style* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Small* | *Medium* | *Large* | *East* | *Central* | *West* | *No* | *Medium* | *High* | *No* | *Yes* | *SP* | *JV* |
| $npa_{t-1}$ | 3.503$^{***}$ | 2.720$^{***}$ | 1.719$^{***}$ | 2.517$^{***}$ | 2.272$^{***}$ | 2.629$^{***}$ | 2.688$^{***}$ | 2.358$^{***}$ | 1.665$^{***}$ | 2.641$^{***}$ | 1.849$^{***}$ | 2.567$^{***}$ | 2.205$^{***}$ |
| | (0.091) | (0.034) | (0.020) | (0.025) | (0.057) | (0.068) | (0.029) | (0.037) | (0.049) | (0.024) | (0.037) | (0.024) | (0.042) |
| $npa_{t-1}^2$ | -0.009$^{***}$ | -0.007$^{***}$ | -0.003$^{***}$ | -0.006$^{***}$ | -0.006$^{***}$ | -0.007$^{***}$ | -0.007$^{***}$ | -0.006$^{***}$ | -0.004$^{***}$ | -0.006$^{***}$ | -0.004$^{***}$ | -0.006$^{***}$ | -0.005$^{***}$ |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| $sa$ | -0.246$^{**}$ | -0.088 | 0.027 | -0.257$^{***}$ | -0.163$^{**}$ | -0.025 | -0.192$^{***}$ | -0.263$^{***}$ | -0.189 | -0.201$^{***}$ | -0.348$^{***}$ | -0.225$^{***}$ | -0.164$^{**}$ |
| | (0.110) | (0.054) | (0.048) | (0.039) | (0.071) | (0.093) | (0.041) | (0.063) | (0.136) | (0.036) | (0.075) | (0.035) | (0.084) |
| $sa_{t-1}$ | 0.101 | 0.031 | -0.034 | 0.105$^{***}$ | 0.092 | 0.010 | 0.073$^{**}$ | 0.159$^{***}$ | 0.137 | 0.085$^{***}$ | 0.270$^{***}$ | 0.109$^{***}$ | 0.066 |
| | (0.089) | (0.045) | (0.042) | (0.033) | (0.061) | (0.086) | (0.035) | (0.055) | (0.122) | (0.031) | (0.068) | (0.030) | (0.075) |
| *sum(cfa)* | 2.222$^{***}$ | 0.433$^{**}$ | -0.244 | 1.212$^{***}$ | 0.381$^{*}$ | -0.529 | 1.204$^{***}$ | -0.028 | -0.414 | 0.951$^{***}$ | -0.623$^{***}$ | 0.761$^{***}$ | 0.132 |
| | (0.376) | (0.190) | (0.152) | (0.145) | (0.208) | (0.456) | (0.153) | (0.209) | (0.410) | (0.133) | (0.227) | (0.126) | (0.300) |
| | [0.058] | [0.024] | [0.012] | [0.064] | [0.027] | [-0.007] | [0.073] | [0.057] | [0.015] | [0.072] | [-0.022] | [0.034] | [0.022] |
| | {11.682} | {2.658} | {0.604} | {12.755} | {2.995} | {-0.340} | {7.843} | {4.606} | {0.482} | {6.764} | {-0.979} | {4.658} | {0.979} |
| *sum(dbta)* | -3.530 | 1.635 | 0.487 | -0.055 | 2.586$^{*}$ | -1.317 | -0.726 | 1.101 | 3.221 | -0.228 | 0.964 | 0.288 | 3.180 |
| | (2.990) | (1.307) | (0.974) | (1.101) | (1.492) | (1.954) | (1.066) | (1.546) | (3.424) | (0.987) | (1.219) | (0.892) | (2.865) |
| Wald test of exogeneity | 14.90 | 8.43 | 3.08 | 68.24 | 12.07 | 10.15 | 40.03 | 27.64 | 4.19 | 45.87 | 37.20 | 54.35 | 8.92 |
| (p-value) | (0.002) | (0.038) | (0.379) | (0.000) | (0.007) | (0.017) | (0.000) | (0.000) | (0.242) | (0.000) | (0.000) | (0.000) | (0.030) |
| Observations | | | | | | | | | | | | | |
| Left-censored | 33,695 | 60,408 | 20,721 | 85,979 | 16,411 | 12,434 | 81,586 | 30,274 | 2,964 | 103,807 | 11,017 | 99,883 | 14,707 |
| Uncensored | 2,288 | 7,687 | 8,115 | 12,964 | 2,568 | 2,558 | 11,192 | 5,130 | 1,768 | 14,675 | 3,415 | 14,652 | 3,405 |

Notes: The dependent variable npa (new products/total assets) is a censored variable which takes its real value if the firm has positive new products output (uncensored observations), and zero otherwise (left-censored observations). Outliers in all regression variables are trimmed at the 1% and 99% level. We estimate the augmented Euler equation using the IV Tobit estimators. Heteroskedasticity-consistent standard errors are reported in parentheses. $^{***}$, $^{**}$ and $^{*}$ indicate significance at 1%, 5% and 10% level respectively. Time dummies, industry dummies and time-industry interaction terms are included in all specifications but not reported in this results table. We instrument sales and all financing variables using their own values lagged twice (t-2) in the IV Tobit regression. *P*-values of the Wald test of exogeneity are shown in parentheses. The numbers in square brackets are marginal effects on the probability of being uncensored, and in curly brackets are marginal effects on uncensored observations. See Appendix for complete definitions of all variables and criteria of all classifications.

# Appendix

**The National Medium- and Long-Term Program of Science and Technology Development (2006-2020)**

Table 3.A1 presents details of the main areas of responsibility and total number of supporting policies by department characterizing the plan.

**Definition of the variables used**

*New products*: new product sales.

*Sales*: firms' total sales (including domestic and overseas sales).

*Cash flow*: net income plus depreciation.

*New long-term debt issue*: difference between long-term debt in period *t* and *t-1*.

$\Delta$*Cash holdings*: difference between cash & cash equivalents in period *t* and *t-1*, where cash & cash equivalents are proxied as the difference between current assets - stocks - accounts receivable.

*Total assets*: sum of the firm's fixed and current assets, where fixed assets include tangible fixed assets, intangible fixed assets, and other fixed assets; and current assets include inventories, accounts receivable, and other current assets.

*Total liabilities*: sum of current liabilities and non-current liabilities, where current liabilities include bank loans, accounts payable, and other current liabilities; and non-current liabilities include long-term debt and other non-current liabilities.

*Age*: firms' age, from the year they established to the year *t*.

*Sales growth*: log-difference between real sales in period *t* and *t-1*.

*Assets growth*: log-difference between real total assets in period *t* and *t-1*.

*Employee growth*: log-difference between number of employees in period *t* and *t-1*.

*Labor productivity*: ratio of total real sales to number of employees.

*Wage per employee*: ratio of total real wage bill to number of employees.

*Leverage*: ratio of total liabilities to total assets.

*Liquidity*: difference of current assets and current liabilities to total assets ratio.

*Coverage*: ratio of operating profits to interest payments.

*Deflators*: all variables (except tangible fixed assets) are deflated using provincial ex-factory producer price indices taken from various issues of the China Statistical Yearbook. Tangible fixed assets are deflated using a deflator for fixed capital formation.

*Region*: coastal=1; central=2; west=3.

*Political affiliation*: Lishu=10, affiliated at central level; Lishu=20, affiliated at provincial level; Lishu=40: city or district level; Lishu=50, county level; Lishu=61, street level; Lishu=62, town level; Lishu=63, township level; Lishu=71, community level; Lishu=72, village level; Lishu=90, no political affiliation.

**Classification criteria:**

| | | |
|---|---|---|
| *Ownership (based on the majority average ownership shares)* | SOEs | At least 50% shares are state owned |
| | Foreign | At least 50% shares are foreign owned |
| | Private | At least 50% shares are privately owned |
| | Collective | At least 50% shares are collectively owned |
| *Ownership (based on 100% paid-in capital rule)* | SOEs | 100% shares are state owned |
| | Foreign | 100% shares are foreign owned |
| | Private | 100% shares are privately owned |
| | Collective | 100% shares are collectively owned |
| *Size* | Small | If a firm’s total real assets are in the lowest quartile of the distribution of total real assets of all firms belonging to the same industry and same year |
| | Medium | If a firm’s total real assets are in the second or third quartiles of the distribution of total real |

| | | |
|---|---|---|
| | | assets of all firms belonging to the same industry and same year |
| | Large | If a firm's total real assets are in the highest quartile of the distribution of total real assets of all firms belonging to the same industry and same year |
| *Region* | East /Coastal | If a firm is located in the coastal region, which includes the following provinces/autonomous regions/municipal cities: Beijing, Tianjin, Hebei, Liaoning, Jiangsu, Shanghai, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Guangxi |
| | Central | If a firm is located in the central region, which includes the following provinces/autonomous regions/municipal cities: Shanxi, Inner Mongolia, Anhui, Jiangxi, Heilongjiang, Jilin, Henan, Hubei, Hunan |
| | West | If a firm is located in the western region, which includes the following provinces/autonomous regions/municipal cities: Qinghai, Sichuan, Gansu, Yunnan, Xinjiang, Shaanxi, Guizhou, Chongqing, Ningxia, Tibet |
| *Political Affiliation* | No | If a firm has no political affiliation (Lishu=90) |
| | Medium | If a firm is affiliated at city or district level, or county level, or street level, or town level, or township level, or community level, or village level (Lishu>20 & Lishu<90) |
| | High | If a firm is affiliated at central level or provincial level (Lishu<=20) |
| *State Shares* | No | If a firm does not have any state shares |
| | Yes | If a firm has some state shares |

| | | |
|---|---|---|
| *Organization style* | SP | Sole proprietorships (if there is only one owner) |
| | JV | Joint-ventures (collaboration or association of any two or more firms owned by different agents, undertaken for mutual profit) |

**Table 3.A1: The National Medium- and Long-Term Program of Science and Technology Development (2006-2020): Areas of Responsibility and Total Number of Supporting Policies by Department**

| *Leading Department* | *Total number of supporting policies* | *Areas of responsibility* |
|---|---|---|
| National Development and Reform Commission | 29 | • Venture capital, corporate bonds, innovation funds<br>• Strengthening indigenous innovation<br>• Strengthening innovation in small and medium-sized enterprises<br>• Encouraging credit guarantee institutions for small and medium-sized enterprises<br>• Reducing tax exemption on foreign invested projects<br>• Industrial technology policy<br>• Strengthening public venture capital funds<br>• Independent innovation capabilities |
| Ministry of Finance | 21 | • Financial policies to support or encourage innovation in enterprises<br>• Public procurement<br>• Providing ECI (export credit insurance) for high- tech export firms |
| Ministry of Science and Technology | 17 | • Incubators and science parks<br>• Measures for supporting research and application of significant technologies<br>• Popularizing science |
| Ministry of Education | 9 | • Universities<br>• Attracting overseas talent |
| Ministry of Finance, State Administration of Taxation | 4 | • Tax incentives to encourage innovation in enterprises |
| Ministry of Personnel | 4 | • Increasing education of personnel in scientific fields<br>• Encouraging the return of overseas Chinese |
| Ministry of Commerce | 2 | • Encouraging technology and innovation import |
| China Banking Regulatory Commission | 2 | • Strengthening financial service for high tech firms |
| China Insurance Regulatory Commission | 2 | • Regulations on investing insurance funds in venture capital enterprises |
| State-owned Assets Supervision and Administration Commission | 2 | • Innovation and S&T management in state-owned enterprises |
| Ministry of Information Industry | 1 | |

| | | |
|---|---|---|
| China Development Bank | 1 | • Soft loans to enterprises in national high tech- fields |
| Export-Import Bank of China | 1 | • Instruments (special accounts) for supporting the development of high-tech enterprises |
| General Administration of Customs | 1 | |
| Ministry of Central Military Equipment | 1 | |

*Source:* State Council of the People's Republic of China, "Consolidated List of the Rules for Implementation of the Supporting Policies for the 'The National Medium- and Long-Term Program of Science and Technology Development (2006-2020)' Formulated by Relevant Department", 2006 http://www.gov.cn/gongbao/content/2006/content_310755.htm

# Chapter 4

# Herding Behavior in Innovation Activities: Evidence from China

In this chapter, using data on 19,722 Chinese innovative firms over the period 2000−2007, we first investigate the extent to which these firms display herding behavior in their innovation activities, and then assess the impact of this behavior on corporate productivity. Based on a variety of different specifications, we find strong evidence in favor of herding in Chinese firms' innovation activities. In particular, private, small firms, with no political affiliation are more likely to herd. We also find that innovation herding has a negative effect on productivity.

## 4.1. Introduction

There are innumerable social and economic situations in which our behavior is influenced by the decisions of others. The term herding is defined to include any behavioral pattern whose similarity with that of other individuals is attributable to interaction with these individuals (Hirshleifer and Hong Teoh, 2003). Herding originally refers to collective animal behavior, but has been extended in social psychology to describe how individuals in a group can act together without a planned direction. In the fields of Economics and Finance, existing research has analyzed herding behavior among investors (Bowe and Domuta, 2004; Tan et al. 2008), mutual fund managers (Lakonishok et al., 1992; Wermers, 1999), and financial analysts (Trueman, 1994; Welch, 2000; Hong et al., 2000; Clement and Tse, 2005).

As the main participants in markets, firms are actively involved in several activities, and their behavior is certainly influenced by that of other firms. One of these activities is innovation. Although innovation naturally lends itself to herding, surprisingly, the literature on herding behavior has neglected this particular corporate activity. Our research fills this gap.

In a perfect market, innovation should be a firm-level idiosyncratic activity. Firms should make innovation decisions individually by considering their financial capacity (e.g. the amount of free cash flow available to them), assessing their willingness to undertake risky activities, and taking into account the value of and social demand for new products. However, due to high adjustment costs and the high uncertainty of innovation activities (Hall, 1992; Hall and Lerner, 2010), innovative firms generally suffer more from asymmetric information than their counterparts who do not engage in innovation activities. It is therefore often difficult for the managers of innovative firms to assess the value of potential new projects. In other words, private information on specific innovation projects is limited. Yet, it is reasonable to believe that managers are aware of the average innovation investment made by other firms in the same industry, which can be viewed as public information. Given that private information is limited, one strategy for managers is to mimic the behavior of their peers, based on public information. Lieberman and Asaba (2006) propose that imitation is a natural response to environmental uncertainty. Therefore, firms' innovation activities tend to some degree to "move with the market" or "follow the general market trend".

As a central element in endogenous growth models, innovation has been widely considered as a key driver of economic growth (Romer, 1990; Aghion and Howitt, 1992) and productivity growth (see Griliches, 1998, for a survey). The effects of herding are more controversial. In the financial realm, it has been found that herding reduces price efficiency (Froot et al., 1992; Shiller, 2003), raises risk and instability (Acharya and Yorulmazer, 2007; Beck et al., 2013), and increases the danger of financial crisis contagion (Chari and Kehoe, 2004; Borensztein and Gelos, 2003). Moreover, earlier research provides evidence that herding behavior generally hurts shareholders' interests (Scharfstein and Stein, 1990; Zwiebel, 1995) and has a negative effect on firm performance and productivity growth (Knyazeva et al., 2008). By contrast, Bo et al. (2013) find that investment herding is positively related to the performance of Chinese firms. Similarly, Wagner (2008) argues that herding among banks is beneficial as it decrease optimal capital charges.

Due to the beneficial effects of innovation and the mixed effects of herding, our objective is to investigate the extent to which herding applies to the innovation activities of Chinese firms, and to assess its impact on corporate productivity.

China is an ideal laboratory to study herding behavior in innovation activities. Chinese firms have in fact exhibited very high growth rates in the last three decades due to China's successful economic transition (Allen at al., 2005; Guariglia et al., 2011). Scholars attribute this phenomenal development to productivity growth, rather than capital or labor accumulation (Zheng et al., 2009; Brandt et al., 2012). Promotion of firm-level productivity may be exemplified through technological innovation. China has also become a major participant in the global markets. In this environment, China's innovation system has undergone considerable changes, and its innovation performance has improved remarkably.[19] However, Chinese firms' innovation activities started late and still face considerable challenges. The most significant challenge is that most Chinese firms, especially privately-owned firms, lack indigenous and original innovation capability, so they often imitate or even copy their counterparts' technology.[20] Furthermore, the Chinese market is generally considered as a new market with a high degree of asymmetric information, due among other things to its unsound property rights protections and poorly regulated patent legal system, as well as its weak shareholders' protection and weak corporate

[19] According to the OECD (2010), gross expenditure on R&D in China increased consistently from 0.73% of GDP in 1991 to 1.5% in 2008. This is even more impressive considering that China's GDP has simultaneously grown on average by close to 9% per year. The business sector's share of total R&D expenditure has also dramatically increased, from 30% in 1994 to 70% in 2008. Considering that since 2004, China is the second largest recipient of foreign direct investment (FDI) in the world, it has become an attractive country for future R&D investment, and, in recent years, foreign companies have established hundreds of new R&D centers in the country. In 2006, China overtook the U.S. and the E.U. to become the largest exporter of high-tech products worldwide (World Bank, 2008). Chinese government report also shows that high-tech products relative to the total volume of export have risen from 20.8% in 2002 to 28.9% in 2012 (Ministry of Commerce, 2012).

[20] Source: "Chinese private firms lack innovation spirit: report", People's Daily Online, website: http://english.peopledaily.com.cn/90778/8067864.html.

governance system. Herding is therefore more likely to take place in such an uncertain environment.

We contribute to the literature along the following three dimensions. First, existing work has mainly analyzed herding behavior in stock markets, but very few papers have empirically tested herding on corporate activities, especially in China. Building on the work by Knyazeva et al. (2008), and Bo et al. (2013) and Chen et al. (2013), who focus their analyses of herding on firms' corporate investment respectively in the US and China, we investigate the extent to which herding affects innovation activities and analyze its impact on firm productivity in the Chinese context. Second, like Chen et al. (2013), we conduct our empirical analysis based on a very large database, compiled by the Chinese National Bureau of Statistics (NBS) over the period 2000−2007. Yet, unlike them, we only focus on innovative firms. Our database is made up of 19,722 mainly unlisted innovative firms operating in 31 provinces or province-equivalent municipal cities. By contrast, Bo et al. (2013) analyze herding only based on Chinese listed firms (1,155 firms during 1999−2004). Yet, listed firms are very few in China, and are not representative of the whole Chinese market. Third, advancing previous literature, we take into account various aspects of firm heterogeneity in our analysis.

Based on a variety of specifications, we find that herding affects Chinese firms' innovation activities, and is more likely to prevail in private firms, small firms, and firms with no political affiliation. Furthermore, we find that innovation herding has a negative effect on firm productivity.

The remainder of this chapter proceeds as follows. Section 4.2 reviews the literature on the causes of herding. Section 4.3 puts forward our hypotheses. Section

4.4 introduces our database. Section 4.5 illustrates our models and estimation methodology. Section 4.6 presents summary statistics. Section 4.7 describes our main empirical results, and robustness tests are presented in Section 4.8. Section 4.9 sets forth our conclusions.

## 4.2. Literature review

Although herding in stock markets has received considerable attention in the US market (Lakonishok et al., 1992; Grinblatt et al., 1995; Wermers, 1999; Nofsinger and Sias, 1999) and in other countries (Wylie, 2005; Walter and Weber, 2006; Uchida and Nakagawa, 2007; Tan et al., 2008), little is known about herding behaviour in corporate activities. Some studies provide theoretical explanations why managers mimic the behavior of others due to payoff externalities, information externalities, and principal-agent concerns. The other branch of literature provides empirical findings.

### 4.2.1. Theoretical reasons

Payoff externalities involve convergence or divergence of behavior arising from the fact that the payoff to an individual’s action is affected by others who take the same action. Bulow et al. (1985) demonstrate that, if agents’ strategies are “strategic complements”, each agent’s incentive to act in a certain way increases as others agents act this way as well. In such a case, positive payoff externalities are generated and agents have an incentive to act alike. The most relevant example in the literature concerns herding behavior in IT adoption, which can be affected by network externalities. Recent studies have indicated that many technology markets are subject to a positive network feedback, which makes the leading technology grow more dominant (Brynjolfsson and Kemerer, 1996; Gallaugher and Wang, 2002; Kauffman et al., 2000). Drehmann et al. (2007) explain that the more users adopt a given technology, the easier the interactions between them, and the lower the incompatibility cost. Kauffman and Li (2003) demonstrate that, in the presence of network externalities, herding increases the payoffs and decreases risk. Positive payoff externalities can therefore contribute to explain herding behavior in the market.

Herding due to informational cascades occurs if an agent imitates previous agents' decisions, to the point where they completely ignore their private information or do not give it appropriate weight (Bikhchandani et al., 1992; Welch, 1992). Since actions are more publicly visible than private information, a successor will try to infer his predecessors' information from their actions. Kauffman and Li (2003) document that, due to information asymmetries and information incompleteness in the technology market,[21] decision-makers try to learn valuable information by observing others' IT adoption actions. This is called observational learning. Informational cascades occur when sufficient observational learning has been accumulated to overwhelm a decision-maker's imprecise private information. For example, a firm decision-maker with the most negative private information (e.g. no profit or even loss from investing in a particular innovation project) may be swayed to invest anyway if he/she observes that three peers in the same industry previously invested. In this case, the information coming from the actions undertaken by the

[21] Information asymmetries refer to the situation in which some decision-makers access less relevant information than others. Information incompleteness refers to the situation in which some decision-makers do not have complete information.

peers would outweigh the private negative information. Devenow and Welch (1996) illustrate a list of empirical phenomena, including the investment decision in R&D, which may be explained by information cascades.

Recent developments in the principal-agent theory provide a new perspective on researching managerial incentives that could foster investment herding. Traditional capital budgeting theory suggests that, in order to maximize firms' profits, managers should make investment decisions based on expected returns. However, when making decisions, managers may have incentives to deviate from the profit-maximizing goals in order to pursue their own interests, i.e. enhance their reputation in the labour market. In *The General Theory*, Keynes (1936) suggests that "it is better for reputation to fail conventionally than to succeed unconventionally". This statement motivates Scharfstein and Stein (1990) who document that smart managers receive signals with high precision, therefore their informative (true) private information is correlated with that of other smart managers, and hence they will tend to make similar investment decisions. However, dumb managers tend to receive uninformative signals (noise), as consequences, they will mimic smart managers' behavior, in order to conceal the poor quality of these signals and maintain their reputation, even at the time when smart managers make wrong decisions. In addition, Scharfstein and Stein (1990) discuss the potential application of herding behavior to the adoption of new technologies. They found reputational externality is created when a leading firm in the industry adopts new technology. For the reputational concern, other managers in the same industry will tend to be biased toward the new technology in order to keep up competition.[22] Zwiebel (1995)

[22] Graham (1999) tests theoretical herding model developed by Scharfstein and Stein (1990). Using U.S sample of investment newsletter asset allocation recommendations, and identifies the attributes of newsletters that herd on the advice of "market leader".

models corporate conservatism in which reputational concerns may lead managers to refrain from deviating from the herd. If enough managers have adopted a certain technology, subsequent managers prefer to adopt this technology instead of a possibly superior but proprietary technology. This is because, an ex-post bad outcome under an ex-ante new action could be attributed to bad governance and result in a consequent loss of power, whereas an ex-post bad outcome under the ex-ante old action may be rationalized as "beyond government control", as evidenced by similar bad outcomes in peers. Given the high uncertainty characterizing innovation activities, managers would rather herd than take risks.

In addition, relative performance evaluation (Palomino, 2005; Albuquerque; 2009; Albuquerque et al., 2013; Gong et al., 2011) also contributes to explain herding behavior in corporate investment. It is argued that managers' performance is evaluated not individually but relative to their peer groups. In this case, managers may mimic the actions of other managers, completely ignoring private informative, to maintain their reputation and avoid being considered as low-ability managers.

### 4.2.2. Empirical findings

Only a few papers empirically test herding in corporate investment. Based on a panel of UK public non-financial firms over the period 1994−2003, Bo (2006) finds a negative relationship between managers' reputation and investment deviation. They argue that those managers who are particularly concerned with reputation are more likely to herd when making investment decisions. The author measures the manager's reputation by the pay received in the managerial labor market. Further findings show that large public firms are more closely monitored by the public, are experiencing more reputational concerns, and therefore their managers have stronger incentives to follow the herd than small firms.

Using both US and non-US data, Knyazeva et al. (2008) find that investment is more likely to comove when firms rely on public information rather than on firm-specific private information about investment opportunities. Moreover, weakly governed managers generally comove more in their investment decisions, as they tend to shirk in the process of acquiring information. This effect is found to be stronger for firms with a high share of specialized assets and in high information intensive industries (such as, for example, IT-intensive industries). The authors also find that investment comovement is decreasing in property rights and shareholder rights protection, and increasing in the degree of information asymmetry. This can be explained considering that weak property rights erode the expected return on firm value creation and thus reduce private information acquisition, and hence increase investment comovement. Shareholder rights protection increases ex ante and ex post of outside shareholders to limit insiders' self-dealing transactions. Similarly, firms faced with high information asymmetries may opt for investment based on verifiable public information, which would result in an increase in investment comovement. Finally, Knyazeva et al. (2008) show that investment comovement negatively affects profitability at the firm and industry level, as well as productivity growth at the country level.

Based on 1,155 Chinese listed non-financial firms over the period 1999−2004, Bo et al. (2013) examine whether board attributes can help to explain investment herding. Specifically, corporate boards are more like to herd in their investment decisions if they are relatively large and have more young/female/independent directors, and if their CEO is not the chairman of the board. Surprisingly, the results show a positive relationship between investment herding and firm performance. The authors explain this considering that when firms operate in an environment with high uncertainty or high asymmetric information such as the Chinese environment, private information may contains large amount of noise, which cannot ensure managers achieving positive investment outcomes. Under such circumstances, it is safer for managers to herd in the crowd.

Chen et al. (2013) use a large Chinese sample and find a significantly positive relationship between government intervention and investment comovement. This impact is higher and more significant for state-owned firms than foreign and private firms. This happens because the Chinese government has a greater influence on state-owned firm, and their corporate investment decisions. Further, the authors show that investment comovement has a negative impact on corporate performance.

## 4.3. Hypotheses

### 4.3.1. General hypothesis on herding in the Chinese context

The Chinese market is a newly established market. It is therefore characterized by a high degree of information asymmetry. In addition, given high adjustment costs and uncertainty characterizing them, innovative activities are believed to suffer more from asymmetric information than other corporate activities. As many Chinese firms cannot access private information, they have to make their investment decisions, and especially innovation decisions, based on observable public information or simply imitate the actions of other firms. Moreover, compared with other countries, China's property rights protections started late (in 1979), and their patent legal system is unsound, with relatively poor regulation.[23] Therefore, some firms exploit legal loopholes to imitate and even copy other firms' innovation projects. Additionally, shareholders' protection and corporate governance are still weak in China, which aggravates the conflict of interest between principal and agent.

Furthermore, because many Chinese firms lack indigenous and original innovation capabilities, they tend to often imitate or even copy their counterparts' technology. Maskin et al. (2000) demonstrate that a relative performance evaluation system is widely used in China. Under this system, managers' performance not only depends on their own ability, but is also evaluated relative to the performance of their peers. Specifically, a manager's performance is assessed as good, as long as the manager performs no worse than the industry average. This relative performance evaluation provides managers with a strong motivation to follow their peers. In the light of these considerations, we hypothesize that:

***H1****: Herding behavior exists in Chinese firms' innovation activities.*

### 4.3.2. Firm heterogeneity and herding

#### *4.3.2.1. Ownership*

The Chinese corporate world consists of state-owned, foreign, private, and collective enterprises. Because of their strong ties with the central government, SOEs (state-owned enterprises) typically have the advantage of knowing the latest innovation policies. Compared to other firms, they therefore suffer less from asymmetric

[23] Patent protection in modern mainland China began with the promulgation of the Patent Law of the People's Republic of China in 1984, which aims to encourage invention creation and to promote the development of science and technology. To comply with its international obligations, as well as to facilitate its development into an innovative country, China has since amended its Patent Law three times: first in 1992, then again in 2000, and most recently in 2009.

information and are able to search for good innovative projects based on their private information. In addition, high-tech SOEs generally do not hesitate to spend heavily on hiring highly skilled managers, who may help make the right decisions with regard to innovation activities. Furthermore, SOEs are not subject to financing constraints (Guariglia et al., 2011), which enables them to carry on large, costly, but potentially profitable innovation projects. Moreover, because SOEs' innovation activities are directly related to China's social progress and future development, they are generally conducted not just by SOEs but more likely to be operated under the government guidance, which makes their innovation investment more efficient. It is different with corporate investment in Chen et al. (2013) that the decisions are generally made by SOEs' managers who may herd due to the consideration of their reputation in the market. Therefore, compared to other firms, Chinese SOEs are less likely to herd when making innovation decisions. The same is likely to apply to collective firms, given their strong links with local governments.

Coming to foreign firms, we expect them to display a lower innovation herding behavior, first, due to their strong shareholder rights and property rights protection; and second, because of their advanced technology and rich experience in carrying out innovation investment. In addition, they have access to more capital and international product markets, as well as better channels through which to diversify economic risks and balance their financial performance on a global scale (Desai et al., 2004).

Private firms, on the other hand, are typically characterized by a higher degree of informational asymmetries and severe principal-agent conflicts. They can only access limited private information and therefore have a strong incentive to make innovation decisions in the crowd. They also suffer from serious problems in terms of corporate governance, property rights protections, patent legal system, and shareholders' protection (Allen et al., 2005; Lin et al., 2010), which makes them more likely to herd when undertaking innovation activities. We therefore hypothesize that:

***H2a**: Firms owned by private agents are more likely to herd in innovation activities, compared to firms owned by other agents.*

#### *4.3.2.2. Size*

In stock markets, Wermers (1999) posits that informational cascades are more likely in small-capitalization securities because institutional investors would put a relatively smaller weight on their own private information but more on what the herd is doing. Acharya and Yorulmazer (2007) find that small banks have stronger incentives to herd because of the "too-many-to-fail" problem.[24]

Focusing on corporate investment, Knyazeva et al. (2008) find that small firms exhibit a higher degree of investment comovement, because they are likely to face more severe information asymmetries. Using Chinese data, Sami et al. (2014) find that small firms tend to rely more on the publicly available information such as peer group information to negotiate audit fees, but large firm prefer to make decision rely on their private information. Moreover, Ho et al. (2006) point out that large firms are generally more informative and they will make more effort to search for potential R&D project with high growth opportunities, and they can exploit the results of

[24] In their paper, according to the "too-many-to-fail" argument, it is *ex-post* optimal for the regulator to bail out some or all failed banks when the number of bank failures is large, whereas when the number of bank failures is small, failed banks can be acquired by the surviving banks. This gives banks, and especially small banks, an incentive to herd.

innovation better than small firms. Due to the above concerns, small firms may mimic large firms' behavior in order to reap high growth from innovation investment. Based on the arguments above, we hypothesize that:

***H2b**: Small firms are more likely to herd in innovation activities than their larger counterparts.*

#### *4.3.2.3. Political connections*

Li et al. (2008) show that political connections (*guanxi*) give Chinese firms certain advantages, including "better access to key resources that are controlled by the Party and the government, such as business operation licenses, bank loans, land, and eligibility for favorable but discretionary government policies such as tax benefits and the waiver of 'extralegal' fees" (p. 288). Xu et al. (2013) demonstrate that, in a relationship-based economy such as China, building connections with the government or even engaging in politics can facilitate firms' private communication with the state, and hence mitigate information asymmetries, as well as social discrimination. As they are more likely to suffer from information asymmetries, politically unaffiliated firms are more likely to herd in innovation activities. Based on the arguments above, we set forth the following hypothesis:

***H2c**: Firms with no political affiliation are more likely to herd in innovation activities, than their politically affiliated counterparts.*

### 4.3.3. Herding and corporate productivity

The impact of herding has been largely examined in the stock market that it generally destabilizes stock price, increases the volatility on stock return, and even cause temporary price bubbles (Shiller et al., 1984; Barber et al., 2009; Venezia et al., 2011). Au and Kauffman (2003) point out that, once a technology is adopted and its true value is revealed, this technology is proven to be more favorable than other technologies whose value may be uncertain. People are therefore likely to select the "proven" technology, even if the "unproven" one has a much higher expected value. This often generates inefficiencies in the economy. According to Bikhchandani et al. (1998), the information cascades theory implies pervasive but fragile herding behavior, because cascades are triggered by a small amount of individuals containing limited information. In addition, private information may allow firms to explore specific projects that cannot be identified via public information alone. Private information also provides a more accurate assessment of firms' investment opportunities, thus increasing the likelihood of making correct decisions. However, in an information cascade, a firm following the crowd may completely ignore private information or not give it the appropriate weight. In addition, valuable information about new technologies is often lost when a firm blindly follows others' decisions, which negatively affects corporate productivity. Finally, focusing on principal-agent concerns, the managers herd because they pursue their own interest instead of maximizing corporate profits, which once again damage productivity. Based on the arguments above, we hypothesize that:

***H3**: Innovation herding has a negative effect on corporate productivity.*

## 4.4. Data and summary statistics

### 4.4.1. Sample construction

The data we used in this chapter is similar as we used in Chapter 3. But, to analyze firms' innovation herding behavior, we only focus on firms involved in innovation activities, that is, those firms that display positive new product sales.[25] We also follow the similar process and criteria to clean the data as in Chapter 3. For example, we drop observations that make little sense, such as those with a negative value of sales and negative new product sales. Observations with negative values of total assets minus total fixed assets, negative values of total assets minus liquid assets, and negative values of accumulated depreciation minus current depreciation, are also removed from our sample. We also exclude firms with incomplete records on our main regression variables. Finally, in order to control for extreme values, we drop outliers, defined as the 1% and 99% tails of the distribution of our main regression variables. After the above adjustments, our final panel data set includes 45,319 observations, covering 19,722 mainly unlisted firms over the period 2000−2007.[26]

### 4.4.2. Innovation herding measures

In constructing our proxy for innovation herding, we follow the method used in Bo (2006) and Bo et al. (2013). These authors point out that it is reasonable to assume that firm *i* takes the innovation decisions of its peers as reference point. By "peers" we mean other firms operating in the same industry as firm *i*. However, in practice, it is not easy for managers to obtain their peers' private information on investment in

[25] Firms who do not sell new products may choose to do so through herding behavior. Yet, their choice could also be caused by other factors such as the lack of funds, the lack of skilled workers (e.g. scientists, engineers or other specialists); or the lack of technology. As we do not have information on these motivations in our data, we only focus on firms with positive sales of new products. Hereafter, we refer to these firms as innovative firms.
[26] Details about the structure of our panel are provided in Table 4.A1 in the Appendix.

innovation activities. Managers will therefore need to make a forecast based on available public information, which we assume to be given by the average innovation investment of other firms in the same industry in a given year.[27] Our proxy for innovation herding in this research is therefore given by: $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$, which is the absolute value of the difference between the new product sales to total assets ratio of firm *i* in year *t*, $\left(\frac{NP}{K}\right)_{i,t}$; and the average corresponding ratio of other firms operating in the same industry, excluding firm *i*, in that same year, $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$. A smaller deviation suggests that firm *i*'s innovation decisions are very similar to those of other firms in the same industry in the same year, which means more herding. Herding proxies of this type were originally developed in the literature on herding among financial analysts (Lamont, 2002; Graham, 1999; Ashiya and Doi, 2001).

### 4.4.3. Summary statistics

Table 4.1 presents the distribution of the values of innovation herding, measured as $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$, by year and industry. We observe that in the full sample, the average value of herding is 37.51. If we look specifically by year, we find that this value is relatively smaller in the first four years of our sample (i.e. 2000−2003) compared to later years (2005−2007), which means that more herding took place in

[27] Bo et al. (2013) use the previous year's industry average as a reference for fixed investment decisions. Yet, because we consider innovation decisions, and because to keep up with the market in a highly competitive environment, firms need to upgrade fast, we include the contemporaneous industry average in our regressions. The results were robust to using the lagged industry average. These results are available on request.

the early part of our sample. This trend is probably due to China's unsound property rights protections and poorly regulated patent legal system in the early years. Chinese firms' weak shareholders' protection and weak corporate governance may also have played a role. With the "National Medium- and Long-Term Program of Science and Technology Development (2006−2020)" published in 2006, China committed to strengthening indigenous innovation and independent innovation capacity. Moreover, the *Company Law* revised in 2005, provides a new foundation for drawing up a corporate governance framework in China and improved companies' governance structure by protecting lawful shareholders' rights and public interests. These developments can explain why the average values of $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$ rose in the 2005−2007 period, which means less evidence of herding.

[Insert Table 4.1 here]

Looking at the distribution across industries, we observe that the high-tech industries (e.g. chemicals & plastic, machinery & equipment, electrical equipment) contain more innovative firms (19.88%, 19.04%, and 21.26% of the whole sample, respectively), and are more likely to herd, as witnessed by smaller average values of $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$. This can be explained by the high uncertainty and high levels of asymmetric information characterizing high-tech industries.

Table 4.2 presents descriptive statistics for several key variables used in our empirical analysis. As discussed in Table 4.1, the average herding value is 37.51 (median 32.97). The average TFP value is 6.07 (median 4.36). Compared with Ding et al. (2012), who use the same data but calculate TFP based on the whole (innovative and non-innovative) sample of firms, our results suggest that TFP in innovative firms is relatively larger (the average TFP value is 3.34 in their paper). Focusing on the other two productivity measures, the mean of PROD is 2.77 (median 1.92), and the mean of VAPW is 0.42 (median 0.30).[28] Coming to the control variables, we observe that innovative firms are relatively larger (average size, described by the logarithm of total real assets, is 6.38) than average (Ding et al., 2012, report an average size of 5.48). This finding can be explained considering that only large firms with more assets can afford the high adjustment costs associated with innovation activities. Another explanation is that large firms are likely to be more financially healthy, which means they have sufficient financial resources to undertake innovative activities. The average cash flow to assets ratio is 7.71 (median 5.70). In addition, compared to the average firms examined in Ding et al. (2012), innovative firms have more leverage (58.22 compared to 57.81) as they need more financial resources. They also have less collateral (31.26 compared to 34.12, due to their higher intangible assets), a higher sales growth (14.14 compared to 11.61, because of their higher investment opportunities), and are more likely to export (the export dummy takes the average value of 0.56 for innovative firms, compared to 0.34 for the full sample).

[Insert Table 4.2 here]

## 4.5. Model and methodology

### 4.5.1. Baseline models: testing the presence of herding

To test the extent to which Chinese firms exhibit herding when undertaking

[28] *TFP* is the abbreviation of total factor productivity; *VAPW* is the abbreviation of value add per worker; *PROD* is the abbreviation of productivity. See their calculations in Appendix.

innovation activities, we begin by estimating the following two equations:

$$\Delta\left(\frac{NP}{K}\right)_{i,t} = \beta_0 + \beta_1 \Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t} + \beta_2 Size_{i,t} + \beta_3 Salesgrowth_{i,t} + \beta_4 Cashflow_{i,t} + \beta_5 Leverage_{i,t} + \beta_6 Collateral_{i,t} + \beta_7 Expdum_{i,t} + v_i + d_t + \varepsilon_{i,t} \quad (4.1)$$

$$\left(\frac{NP}{K}\right)_{i,t} = \beta_0 + \beta_1 \overline{\left(\frac{NP}{K}\right)}_{-i,t} + \beta_2 Size_{i,t} + \beta_3 Salesgrowth_{i,t} + \beta_4 Cashflow_{i,t} + \beta_5 Leverage_{i,t} + \beta_6 Collateral_{i,t} + \beta_7 Expdum_{i,t} + v_i + d_t + \varepsilon_{i,t} \quad (4.2)$$

where *i* indexes firms, and *t*, time. Equation (4.1) is based on the equation used by Knyazeva et al. (2008) and Chen et al. (2013). It estimates the propensity to herd as the sensitivity of firm-level innovation changes to industry-level changes in innovation. Specifically, if the coefficient $\beta_1$ is positive and significant, this means that firm-level change in new products follow industry-level change in new products. This would suggest that herding behavior may exist, which would prove our Hypothesis 1.

We also estimate Equations (4.2) as a robustness test, with the aim of examining whether firm innovation level is close to the industry average level. Specifically, if the coefficient $\beta_1$ is positive and significant, this means that firms' new products to sales ratios are close to the industry average ratio, which would, once again, indicate the existence of innovation herding and support our first hypothesis.

In order to test Hypothesis 2a, 2b, and 2c, we then differentiate firms based on ownership (state-owned, foreign, and private), political affiliation (high, medium, and low), and size (large, medium, and small), and interact $\Delta\overline{\left(\frac{NP}{K}\right)}$ or $\overline{\left(\frac{NP}{K}\right)}$ with ownership, size, and political affiliation dummies in Equation (4.1) and (4.2) to test the extent to which the sensitivities differ in each category.

Both our equations also include a range of control variables, which are similar to those used in the literature on herding. In particular, $Size_{i,t}$ is the natural logarithm of the firm's total assets. Knyazeva et al. (2008) find that firm size negatively affects the change of investment, because larger firms generally have more financing capacity and invest more consistently, exhibiting therefore less change in their investment. For the similar reason, we expect to observe a negative coefficient on *Size* in Equation (4.1). Yet the predicted sign for *Size* in Equation (4.2) is not clear. On the one hand, small firms are more likely to be innovative since they have a more responsive climate for making quicker decisions to go ahead with new and ambitious projects, a less bureaucratic inertia and more flexible structure, a higher ability to adapt and improve, and fewer difficulties in accepting and implementing change (Chandy and Tellis, 2000). On the other hand, large firms are more likely to be innovative because they have more financial and technical capabilities, the economies of scope to spread the risk of failure and absorb the costs of innovation, the ability to establish and maintain scientific facilities, the resources to hire professional and skilled workers, and the ability to raise capital and market the innovation (Damanpour, 2010).

$Salesgrowth_{i,t}$ is the log-difference between real sales in periods $t$ and $t$-$1$. This is used to represent firms' investment opportunities. Higher investment opportunities indicate high expected investment on innovation. We therefore expect a positive coefficient on *Salesgrowth* in both Equations (4.1) and (4.2).

$Cashflow_{i,t}$ is the ratio of cash flow (net income plus depreciation) to total assets. Its coefficient is expected to be negative in Equation (4.1). This can be explained considering that because innovation has high adjustment costs and is financed with volatile sources, internal cash flow is the cheapest way for firms to adjust the flow of innovation in response to transitory shocks. Therefore, the higher the cash flow of a firm, the stronger the effect on smoothing its innovation expenditures, and the smaller the change in the firm's innovation activities. However, the coefficient of *Cashflow* is expected to be positive in Equation (4.2) since firms' innovation activities are constrained by the availability of internal finance (Guariglia and Liu, 2014).

$Leverage_{i,t}$ is the ratio of total liabilities to total assets. Previous studies have found mixed results on the effect of leverage on R&D investment (Szewczyk et al. 1996; Zantout, 1997; Vincente-Lorente, 2001; O'Brien, 2003). This is not surprising since leverage influences managers' investment behavior in two contrasting manners: positively, through playing a disciplinary role, and negatively, through the presence of agency cost and information asymmetry problems (Ho et al., 2006). Specifically, on the one hand, the disciplinary role of debt has a positive influence on managerial behaviour, driving managers to invest in projects with positive net present value (NPV) such as R&D projects. On the other hand, agency cost problems arise when the principal (debt holders) and the agent (managers) cannot reach a consensus in an R&D investment decisions. Managers sometimes withhold information on innovation to maintain confidentiality for competitive reasons. The less-informative debt holders would therefore ask for a premium when they realize the possible high risks in R&D projects, which raise the cost of the capital, and reduce the attraction of innovation activities. Chen et al. (2013) find insignificant effect on leverage. We therefore keep an open mind about the sign of the coefficient associate with *Leverage*.

$Collateral_{i,t}$ is the ratio of tangible to total assets. On the one hand, it can be used as a proxy for firms' borrowing capacity, which is important in raising funds in credit markets with imperfect information (Wette, 1983; Bester, 1987; Guariglia and Mateut, 2014). Therefore, firms with a higher tangibility of assets are likely to find it easier to borrow external funds. This is especially important for Chinese firms as their innovation activities are generally constrained by the availability of internal finance (Guariglia and Liu, 2014). From this point of view, collateral should have a positive effect on innovation activities. However, Hovakimian (2009) argues that firms with high tangibility are more likely to operate in industries with low growth, and could therefore display lower investment, especially lower investment in risky innovation projects. Additionally, a firm with higher collateral value indicates less intangible assets, such as, patents, copyrights, technology, and therefore, less innovation activities. Based on the argument above, we will keep an open mind about the sign of the coefficient associate with *Collateral*.

$Expdum_{i,t}$ is a dummy variable equal to 1 if the firm reports a positive value of overseas sales, and 0 otherwise. Exporting firms are more likely to connect with foreign firms to incorporate better production techniques or upgrade product quality (Aw et al., 2008), which results in more innovation. Therefore, we expect a positive coefficient on *Expdum* in both Equations (4.1) and (4.2).

Lastly, our Equation includes $v_i$ to indicate the firm-specific component of the error term, which is dealt with by estimating the equation in first-differences. $d_t$ is included to indicate a time-specific component, which controls for macroeconomic fluctuations or business cycle effects and which we take into account by including time dummies in all our specifications. Finally, $\varepsilon_{i,t}$ is an idiosyncratic component.

### 4.5.2. Baseline models: testing the effect of herding on productivity

To test the effects of innovation herding on firm productivity, we then estimate the following equation, which follows Knyazeva et al. (2008), Bo et al. (2013), and Chen et al. (2013)'s approach:

$$Productivity_{i,t} = \beta_0 + \beta_1 Herding_{i,t} + \beta_2 Size_{i,t} + \beta_3 Salesgrowth_{i,t} + \beta_4 Cashflow_{i,t} + \beta_5 Leverage_{i,t} + \beta_6 Collateral_{i,t} + \beta_7 Expdum_{i,t} + v_i + d_t + \varepsilon_{i,t} \quad (4.3)$$

where $Herding_{i,t} = \left| \left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t} \right|$. We proxy $Productivity_{i,t}$ using three different measures. First, we construct firm-level total factor productivity, TFP, using the Levinsohn and Petrin (2003) method.[29] This method has been widely used in recent research (Greenaway et al., 2014; Ding et al., 2012; Chen and Guariglia, 2013). Second, following McGuckin and Nguyen (1995) and Maksimovic and Phillips (2001), we calculate value added per worker, VAPW, which is defined as the value of total real sales net of materials cost of goods sold, divided by the number of workers. Third, we compute average labor productivity, PROD, on total real sales divided by the number of employees (Greenaway et al., 2007; Ding et al., 2012). A positive and significant $\beta_1$ coefficient would suggest that a smaller product innovation deviation (i.e. more product innovation herding) is associated with lower firm productivity, providing support for our Hypothesis 3.

All other independent variables are the same as those included in Equation (4.1) and (2). We expect *Size* to affect productivity positively, as larger firms may benefit

[29] TFP estimates based on the Levinsohn and Petrin (2003) method can be obtained in STATA by using the *levpet* command.

from economies of scale and have better access to external finance (Chhibber and Majumdar, 1999), which might enhance their productivity. Evidence of this can be found in both the theoretical (Melitz, 2003) and the empirical literature (Bernard and Jensen, 1999; Chen and Guariglia, 2013).

As for sales growth, Knyazeva et al. (2008) find that it is positively related with firms' performance but not consistently significant. Bo et al. (2013) find that sales growth is negatively associated with Tobin's Q, but positively linked with ROA. Therefore, the predicted sign for *Salesgrowth* in Equation (4.3) is not clear.

We expect *Cashflow* to have a significantly positive impact on productivity. Because Chinese firms, and especially innovative firms, are generally financially constrained (Guariglia and Liu, 2014), their ability to undertake innovative projects depends on the availability of internal cash flow.

We also expect to observe a positive and significant coefficient on *Leverage*, as a higher debt to assets ratio means the firm has more resources at hand to undertake productivity-enhancing projects. Additionally, lenders are likely to consider firms who obtained more debt in the past as credit worthy and will therefore lend more to them, which once again, will enable the firm to invest more in productivity-enhancing projects.

The predicted sign for *Collateral* is not clear. Using Chinese firm-level data, Chen et al. (2013) find that the effect of tangibility on corporate performance (measured by operating income divided by total assets) is negative and significant for their full sample, state-owned firms, and foreign firms, but is positive and significant for private firms. Similarly, based on US data, Knyazeva et al. (2008) find that tangibility is positively associated with industry average profit, but negatively linked with firms' profitability.

We expect *Expdum* to have a positive effect on productivity. Aw et al. (2008) explain that exporting provides a channel for knowledge acquisition by firms, which allows them to incorporate better production techniques or upgrade product quality.

As in Equations (4.1) and (4.2), we include $v_i$ to indicate the firm-specific component of the error term; $d_t$, to indicate a time-specific component; and $\varepsilon_{i,t}$, an idiosyncratic component.

### 4.5.3. Estimation methodology

We estimate all equations using the first-difference Generalized Method of Moments (GMM) estimator proposed by Arellano and Bond (1991).[30] This methodology has been widely used in recent research (Guariglia et al., 2011; Greenaway et al., 2014; Guariglia and Mateut, 2014). On the one hand, it controls for the unobserved firm-specific heterogeneity by estimating the equations in first differences. On the other hand, it takes potential endogeneity into consideration by using two or more lags of the endogenous regressors as instruments. Time dummies and industry dummies are also included in the instrument matrix.

To evaluate the legitimacy of our instruments and assess whether our model is correctly specified, we use the test for second-order serial correlation of the residuals in the differenced equation ($m2$), and the Hansen/Sargan statistics (or $J$ statistics) for overidentifying restrictions.

If the relevant equation is correctly specified, the variables in the instrument

[30] All our regressions are performed in STATA using the command *xtabond2* developed by Roodman (2009).

set should be uncorrelated with the error term. *m*2 tests the null of no second-order serial correlation of the differenced residuals. If it is rejected, we set the instruments to lag 3 and deeper. Specifically, the *m(n)* test follows an asymptotically standard normal distribution under the null of no $n^{\text{th}}$-order serial correlation of the differenced residuals (Brown and Petersen, 2009; Roodman, 2009).[31] As for the Hansen/Sargan test, Blundell and Bond (1998) and Benito (2005) show that, when samples with a very large cross-sectional dimension are used in estimation, it tends to over-reject the null hypothesis of instrument validity.[32] Given the size of our panel, we are therefore inclined to pay little attention to the *J* test.

## 4.6. Results and discussion

### 4.6.1. Herding behavior in Chinese firms' innovation activities

We first test our Hypothesis 1, i.e. whether herding behavior exists among Chinese firms' innovation activities. Column 1 in Table 4.3 reports our regression results for Equation (4.1). The coefficient on $\Delta\overline{\left(\frac{NP}{K}\right)}$ is 0.992, and significant at the 1% level. This means that the changes in firms' innovation output are positively and significantly related to the changes in the industry average, which can be seen as evidence for herding behavior, and provides support for our Hypothesis 1. Knyazeva et al. (2008) and Chen et al. (2013) also find this positive coefficient in their research.

[Insert Table 4.3 here]

Focusing on the control variables, the cash flow term displays a highly

[31] Deeper lags of the instruments were only included if they improved the specification tests.
[32] Significant Sargan test statistics can be found in estimation results in Nickell and Nicolitas (1999), Benito (2005), Benito and Hernando (2007), Greenaway et al. (2014), and Chen and Guariglia (2013).

significant and negative relationship with the changes in the new products ratio (the cash flow coefficient is -2.539). This is because internal cash flow is the cheapest way for firms to adjust the flow of innovation in response to transitory shocks. Therefore, the higher the cash flow of a firm, the stronger the effect on smoothing its innovation expenditures, and the smaller the change in the firm's innovation activities. The coefficient on size (-19.518) is negative and significant at 10% level, which is consistent with the finding in Knyazeva et al. (2008), suggesting that larger firms exhibit smaller changes in the innovation activities, probably due to their long-time consistent investment. In addition, high sales growth firms and exporting firms exhibit more change in new products, with significant coefficients of 0.211 and 25.879, respectively. Finally, the coefficients on leverage and collateral are not significant.

Column 2 presents the results obtained from the estimation of Equation (4.2). We can see that the coefficient on firm innovation output (0.453) is positive and highly sensitive to the industry average, which, once again, can be seen as evidence for herding, and provides further evidence in support of our Hypothesis 1.

As regard to other variables, the significantly positive coefficient of cash flow (1.215) suggests that internal finance is an important channel to support firms' innovation activities. This finding is consistent with Guariglia and Liu (2014). The coefficient associated with the export dummy (21.837) is positive and significant, which indicates that exporting can enhance Chinese firms' innovation activities. Girma et al. (2008) explain that exporters generally have more opportunities to learn advanced technologies and attract FDI from aboard. The coefficients associated with size, sales growth, leverage, and collateral are not significant.

The $J$ and $m_2$-tests do not indicate any problems with the specification of the models and the choice of instruments.[33] In summary, the result reported in columns 1 and 2 of Table 4.3 suggest that the firms' product innovation activities in China are close to the industry average, and can be seen as evidence in favor of the presence of herding behavior. This provides support for our Hypothesis 1.

### 4.6.2. Herding behavior and firm heterogeneity

We next explore the extent to which innovation herding varies across firms characterized by different ownership, size, and different degrees of political affiliation. To this end, we interact the $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ and $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ variable in all our specifications with dummy variables for State/Foreign/Private firms, Small/Medium/Large firms,[34] and firms with No/Medium/High political affiliation,[35] which are labelled as *CATEGORY1*, *CATEGORY2*, and *CATEGORY3* in Tables 4.4a and Table 4.4b, respectively. Estimating our equations with interactions rather than separate regressions for each group allows us to avoid problems of endogenous sample selection, to gain degrees of freedom, and to take into consideration the fact that firms can transit between groups. It also enables us to test whether the

[33] The *m2* statistic is missing in the equations that use $\Delta\left(\frac{NP}{K}\right)_{i,t}$ as the dependent variable because of an insufficient number of time-series observations.

[34] As discussed in the Appendix, small/medium/large dummies take the value of 1 in a given year if a firm's total real assets are respectively in the lowest/second-and-third/highest quartile of the distribution of the total real assets of all firms belonging to the same industry of that firm in that year, and 0 otherwise.

[35] As discussed in the Appendix, political affiliation (which is called *Lishu* in our dataset) is a categorical variable, which takes the following values: *Lishu*=10, affiliated at central level; *Lishu*=20, affiliated at provincial level; *Lishu*=40, affiliated at the city or district level; *Lishu*=50, affiliated at the county level; *Lishu*=61, affiliated at the street level; *Lishu*=62, affiliated at the town level; *Lishu*=63, affiliated at the township level; *Lishu*=71, affiliated at the community level; *Lishu*=72, affiliated at the village level; *Lishu*=90, no political affiliation. We label firms with *Lishu*<=20 as high political affiliation firms; firms with *Lishu*>20 and *Lishu*<90 as firms with medium political affiliation; and firms with *Lishu*=90 as firms with no political affiliation.

differences in relevant coefficients across different types of firms are statistically significant.

[Insert Table 4.4a here]

[Insert Table 4.4b here]

Table 4.4a shows the estimates of Equation (4.1) augmented with the interaction terms. As in Table 4.4a, the coefficients associated with $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ are all positive and highly significant (at the 1% level) for privately-owned firms (column 1), small firms (column 2), and firms with no political affiliation (column 3), but insignificant for other groups. These findings provide support for our Hypotheses 2a, 2b, and 2c. In addition, the finding on small firm is consistent with Knyazeva et al. (2008), who find that corporate investments of smaller US firms tends to exhibit a higher degree of comovement than that of their larger counterparts. We also report *p*-values associated with F-tests aimed as assessing whether the impact of $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\Delta\left(\frac{NP}{K}\right)_{i,t}$ is equal across various groups of firms-years. The results suggest that the hypothesis is rejected when comparing firms with no political affiliation to firms with high affiliation, and when comparing small and large firms.[36] In addition, the $J$ and $m_2$-tests do not indicate any problems with the specification of the model and the choice of instruments.[37]

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[36] Although the difference in magnitude between the coefficients associated with $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ at privately-owned and state-owned firm-years is not statistically significant, the latter coefficient is not precisely determined. Similarly, although the difference in the coefficients associated with $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ at privately-owned and foreign-owned enterprises is not statistically significant, the latter coefficient is not significant.

[37] Once again, the *m2* statistic is missing in the equations that use $\Delta\left(\frac{NP}{K}\right)_{i,t}$ as the dependent variable because of an insufficient number of time-series observations. The results were robust to estimating

The regression results of Equation (4.2) augmented with the interaction terms are reported in Table 4.4b. Focusing on column 1, which divides firms according to ownership, we observe that, in line with our Hypothesis 2a, the coefficient on $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ is positive and significant for privately firms, but insignificant for SOEs and foreign firms. We also report *p*-values associated with F-tests aimed as assessing whether the impact of $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\left(\frac{NP}{K}\right)_{i,t}$ is equal across various groups of firms-years. The results suggest that the hypothesis is rejected when we compare private firms and state-owned firms, but cannot be rejected when we compare foreign and private firms on the one hand, and state-owned and foreign firms on the other.[38] These findings provide further support for our Hypotheses 2a.

Column 2 differentiates firms according to size (based on total assets). In line with Hypothesis 2b, the coefficient on $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ is positive and highly significant (at the 1% level) for small firms, less significant (at the 5% level) and smaller (0.362 compared to 0.959) for medium-sized firms, and insignificant in for large firms. The differences in the coefficient associated with $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ across small, medium, and large firms are all statistically significant.

Column 3 differentiates firms on the basis of political affiliation. We observe that the coefficient associated with $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ is positive and highly significant (at the 1% level) for firms with no political affiliation, less significant (at the 5% level) and smaller (0.496 compared to 0.574) for firms with medium political affiliation, and

separate regressions for firms belonging to the different groups analyzed. These results are not reported for brevity, but available upon request.

[38] Once again, however, the coefficients for private and foreign firms are not statistically significant.

insignificant for firms with high political affiliation.[39] These findings provide support for our Hypothesis 2c.

The coefficients on other control variables are consistent with our prediction. Moreover, the *J* and $m_2$-tests do not indicate any problems with the specification of the model and the choice of instruments.[40]

In summary, the coefficients on $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ and $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ are consistently positive and significant for private firms, firms with no political affiliation firms, and small firms, which indicate these firms' innovation activities tend to "move with the market", or "follow the general market trend". Although the coefficients for firms with medium political affiliation and medium-sized firms are significant in Table 4.4a, they are no longer significant in Table 4.4b. Finally, the coefficients for firms with high political affiliation and large firms are insignificant in all specification, suggesting that these firms do not exhibit herding in their innovation activities.

### 4.6.3. Impact of innovation herding on firms' productivity

Table 4.5 presents estimation results for Equation (4.3), which tests the relationship between innovation herding and firm productivity. In column 1, productivity is measured using TFP. We observe that the coefficient on the product innovation herding proxy $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$ is highly significant (at the 1% level) with a

[39] Although, according to our F-test, the differences in magnitude between the coefficients associated with $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ for firm-years with no political affiliation on the one hand, and firms with medium/high political affiliation, on the other, are not statistically significant, the coefficients for the high affiliation group are not significant.

[40] Similar results, not reported for brevity, but available from the authors upon request, were obtained if separate regressions were estimated for firms belonging to the different categories analyzed.

positive sign. This suggests that a smaller product innovation deviation (i.e. more product innovation herding) is associated with lower firm productivity. The elasticity of $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$ evaluated at sample means is 0.21, suggesting that a 10% decrease in $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$ leads to 2.1% decrease in TFP. Therefore, if firms are more likely to herd their product innovation towards their industry average level, they are more likely to have lower TFP. Similar results are found when we use PROD (column 2) and VAPW (column 3) as alternative measures of productivity. The elasticity of $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$ evaluated at sample means are 0.12 and 0.18 respectively for PROD and VAPW, suggesting that that a 10% decrease in $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$ leads to 1.2% and 1.8% decrease in PROD and VAPW, respectively. These results indicate that a smaller product innovation deviation (i.e. more product innovation herding) is associated with lower firms' productivity, providing support for our Hypothesis 3.

[Insert Table 4.5 here]

Our findings are consistent with the results in Knyazeva et al. (2008) and Chen et al. (2013), who find that corporate investment comovement hinders firm performance and productivity growth in the US and China, respectively. Yet, Bo et al. (2013) provide evidence that corporate investment herding is positively related to firm performance in Chinese listed firms, suggesting that corporate investment herding does not necessarily hurt shareholders in the Chinese context. They explain that the theoretical prediction of negative herding effects is based on the assumption that the information obtained by the decision-makers is perfect and truly informative.

However, in the case of China, which is characterized by an underdeveloped stock market and high uncertainty, this information contains significant noise. Hence, decision-makers do not necessarily generate positive outcomes based on their private information. Additionally, with no well-established monitoring mechanisms, being in the crowd may provide ordinary shareholders with a sense of security concerning the outcomes of corporate decisions. Our results differ from Bo et al.'s (2013) for two main reasons. First, contrary to us, these authors analyze herding only based on Chinese listed firms (1,155 firms in the period of 1999−2004). As listed firms only make a very small proportion of the population of Chinese firms,[41] their sample is not representative of the whole Chinese market. Furthermore, innovation is by nature a more noisy and uncertain phenomenon than corporate investment. In the case of innovation, it may therefore not be a good strategy to just move with the market or follow the leaders, because even the market and the leader firms may not know where to go next or which innovation project will be successful in the future. Private information is therefore precious for firms and helps them make appropriate decisions. If the decision-makers ignore their private information by following the herd, this may result in distortions. This can explain why in the Chinese context, innovation herding may have a negative effect on firms' productivity, even though corporate investment herding has a positive effect.

Focusing on the control variables, we observe that the coefficients on size are all positive and significant. This is reasonable as larger firms have been often found to have higher productivity in both the theoretical (Melitz, 2003) and the empirical literature (Bernard and Jensen, 1999; Chen and Guariglia, 2013). In addition, cash flow is positively and significantly associated with firms' productivity. Because

[41] For example, in 2007, there were only 1,550 listed firms in China. Yet, our database contains 93,552 firms in that year.

Chinese firms, and especially innovative firms, are generally financially constrained (Guariglia and Liu, 2014), they generally finance their innovation projects with internal cash flow. The positive and significant coefficient on leverage can be explained considering that, when internal cash flow is exhausted, firms have to borrow external funds to support their innovation activities. Therefore, both internal cash flow and external borrowing are important for firms to sustain their innovation projects, and achieve higher productivity. The coefficients on other variables are not significant.

Having found that private firms, small firm, and firms with no political affiliation are more likely to herd in innovation activities, we next investigate the extent to which innovation herding hurts the performance of those three categories of firms. The results are presented in Table 4.6. We observe that the coefficients associated with our herding proxy $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$ are significant and positively signed in all specifications. This suggests that a smaller product innovation deviation (i.e. more product innovation herding) is associated with lower firm productivity for the three categories of firms, and provides further support for our Hypothesis 3.

[Insert Table 4.6 here]

## 4.7. Robustness tests

### 4.7.1. Replacing average $\overline{\left(\frac{NP}{K}\right)}_{i,t}$ with median $\overline{\overline{\left(\frac{NP}{K}\right)}}_{i,t}$

Instead of using mean values of investment to total assets ratio, Knyazeva et al. (2008) and Chen et al. (2013) use medians of investment to total assets ratio to measure average industry-level investment. When a distribution is skewed, the median can in fact be seen as a better measure of the mid-point. In Table 4.7, we verify whether our results are robust to using median instead of mean industry-level innovation values in new products to total assets ratio. In column 1, we observe that the product innovation change is still significantly and positively related to the median product innovation, $\Delta\overline{\overline{\left(\frac{NP}{K}\right)}}_{-i,t}$. Similarly, the results in column 2 show that firm product innovation ratio are also highly sensitive to the industry median level, $\overline{\overline{\left(\frac{NP}{K}\right)}}_{-i,t}$. These results confirm that herding behavior exists in Chinese firms' innovation activities, providing further support for our Hypothesis 1.

[Insert Table 4.7 here]

The results in column 3 to 5 represent the impact of innovation herding on firms' productivity, whereby the new herding variable is calculated as $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\overline{\left(\frac{NP}{K}\right)}}_{-i,t}\right|$, where $\overline{\overline{\left(\frac{NP}{K}\right)}}_{-i,t}$ is the median value of new product ratio in this industry excluding firm *i* in year *t*. We observe that the coefficient on this new herding variable is still positive and significant, which confirms that innovation herding has a negative impact on firms' productivity, and once again, provides support for our Hypothesis 3.[42]

### 4.7.2. Testing the impact of innovation herding at industry-level

Chen et al. (2013), Kynazeva et al. (2008), and Morck et al. (2000) use the industry-

[42] All the results are robust in private firms, small firms, and firms with no political affiliation when we take into account the median industry-level innovation values in new products to total assets ratio.

level comovement index to capture herding in investment, which is calculated as:

$$Comove(I) = Max(N_{I\_incr}, N_{I\_decr})/N$$

where $I$ is the corporate investment ratio calculated as the sum of property, plant and equipment and depreciation, deflated by the firm's total assets. They define the index as the ratio of the highest between the number of firms which increase their investment ($N_{I\_incr}$) and the number of firms which decrease their investment ($N_{I\_decr}$) to the total number of firms ($N$), in a specific industry and a given year.[43] In a similar vein, we can calculate an innovation comovement index as following:

$$Comove(NP) = Max(N_{NP\_incr}, N_{NP\_decr})/N$$

where $NP$ is the new product sales deflated by the firm's total assets. *Comove(NP)* measures the proportion of firms that increase (or decrease) new products in a specific industry and year. A higher *Comove(NP)* value implies that companies tend to comove more in their new products within a given industry and year, which means more innovation herding.

We next assess how *Comove(NP)* affects corporate productivity. We expect the effect to be negative. The regression results are presented in Table 4.8. Based on GMM estimates, we observe that *Comove(NP)* has a negative and significant effect on productivity. The *Comove(NP)* elasticity evaluated at sample means are -0.65, -

[43] Chen et al. (2013) use province or province-equivalent municipal cities-level data to construct a regional-industry-time ratio to measure investment comovement. We do not take the regional effect into our consideration for two reasons. First, as we only include innovative firms, our observations (45,319 in total) are less than Chen et al. (2013)'s, who analyze herding in corporate investment using 556,221 observations. If we follow Chen et al. (2013)'s method and divide our sample into different regions and different industries, our observations will decrease significantly in each regional-industry group. Second, we believe that firm managers would consider their peers' innovation actions in the whole market, and not just within a specific province. Therefore, we do not consider the regional effect at the province or province-equivalent municipal cities level. However, we add robustness tests by calculating the regional-industry-time new product comovement, based on a larger region classification (East, Central, and West). Our main findings still hold (see columns 4, 5, and 6 in Table 4.8). See the Appendix for a list of the provinces comprising the Eastern, Central, and Western regions.

1.04, and -1.38 respectively for TFP, PROD, and VAPW, suggesting that a 10% increase in *Comove(NP)* leads to a 6.5%, 10.4%, and 13.8% decrease in TFP, PROD, and VAPW, in column 1, 2, and 3, respectively. This provides further support for our Hypothesis 3. Based on regional-industry-time constructing *Comove(NP)*,[44] we find the results still hold for PROD (in column 5) and VAPW (in column 6). Although the coefficient is not statistically significant for TFP in column 4, it still displays a negative effect. Kynazeva et al. (2008) also use this herding measure to test its relationship with the US firms' operating performance and find a negative relationship, which is consistent with our findings.

[Insert Table 4.8 here]

Focusing on the control variables, *Size* and *Cash flow* are consistently significant in all equations and have a positive effect on productivity. This indicates that large firms and firms with more internal financing are more likely to display higher productivity. These findings are consistent with empirical findings in literature and with our results in Table 4.5. The Sargan tests for instrument validity do not give cause of concern, but the *m2* statistic is missing because of an insufficient number of time-series observations.[45]

## 4.8. Conclusion

Making use of a panel of 19,722 Chinese innovative firms over the period 2000–2007, we explore the extent to which herding affects corporate innovation activities and investigate the impact of herding on firms' productivity. We find

[44] See the calculation in footnote 28.
[45] The first time-series observation for each firm is lost as our herding measures based on the increase (or decrease) in new products for each firm.

strong evidence in favor of herding, which is more likely to affect private, small firms, with no political affiliation. We also find a negative impact of innovation herding on firm productivity.

Our findings suggest that relevant policies should be established to reduce herding behavior in Chinese firms' innovation activities, especially for private, small firms, with no political affiliation. To this end, the Chinese government should endeavour to establish a sound protection of property rights, and a strong regulated patent legal system. At the same time, information disclosure and information exchange should be encouraged to reduce asymmetric information. Finally, Chinese firms should enhance shareholders' protection and further improve corporate governance to reduce principal-agent problems.

Further research needs to be undertaken in the following directions. First, as our regressions are only based on production innovation, it would be interesting to test whether they are robust to using other innovation measures, such as R&D investment. Second, one could test whether our results also hold for listed firms. Third, it would be interesting to test the extent to which Chinese firms herd following industry leaders instead of herding following the industry average. Finally, one could investigate whether similar results apply to other developing countries.

**Table 4.1: Distribution of the number of observations by year and industry**

| | ***Mean*** | ***Observations*** | ***Frequency*** |
|---|---|---|---|
| ***Year*** | | | |
| *2000* | 30.01 | 2,929 | 6.46 |
| *2001* | 32.29 | 4,327 | 9.55 |
| *2002* | 34.71 | 5,300 | 11.69 |
| *2003* | 35.13 | 5,902 | 13.02 |
| *2005* | 40.86 | 9,012 | 19.89 |
| *2006* | 39.86 | 9,591 | 21.16 |
| *2007* | 40.03 | 8,258 | 18.22 |
| ***Industry*** | | | |
| *Metal & Metal products* | 47.00 | 2,834 | 6.25 |
| *Nonmetal products & Petroleum processing* | 40.68 | 2,442 | 5.39 |
| *Chemicals & Plastic* | 38.04 | 9,011 | 19.88 |
| *Machinery & Equipment* | 30.42 | 8,629 | 19.04 |
| *Electrical equipment* | 37.24 | 9,633 | 21.26 |
| *Transport equipment* | 31.15 | 3,708 | 8.18 |
| *Food & Tobacco* | 30.82 | 1,512 | 3.34 |
| *Textile* | 48.06 | 4,387 | 9.68 |
| *Leather & Timber & Furniture* | 40.35 | 2,215 | 4.89 |
| *Mining & Logging* | 43.56 | 948 | 2.09 |
| ***Total*** | 37.51 | 45,319 | 100.00 |

*Notes*: Innovation herding is calculated as $\left|\left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$, where *i* indexes firms and *t*, time. *NP* indicates the sale of new products, and *K*, total assets. The year 2004 is missing because the variable *Newproducts* is not available in that year.

## Table 4.2: Descriptive statistics

| | *Mean* | *Median* | *S.D.* | *Min* | *Max* | *Observations* |
|---|---|---|---|---|---|---|
| ***Innovation variable:*** | | | | | | |
| *New products/Total assets* | 42.12 | 24.60 | 48.12 | 0.12 | 291.28 | 45,319 |
| ***Innovation Herding variable:*** | | | | | | |
| $\left\lvert \left(\frac{NP}{K}\right)_{i,t} - \overline{\left(\frac{NP}{K}\right)}_{-i,t} \right\rvert$ | 37.51 | 32.97 | 30.22 | 0.85 | 214.03 | 45,319 |
| ***Productivity variables:*** | | | | | | |
| *TFP* | 6.07 | 4.36 | 5.30 | 0.34 | 34.77 | 45,319 |
| *PROD* | 2.77 | 1.92 | 2.68 | 0.19 | 20.34 | 45,319 |
| *VAPW* | 0.42 | 0.30 | 0.36 | 0.04 | 2.33 | 45,319 |
| ***Control variables:*** | | | | | | |
| *Size* | 6.38 | 6.36 | 1.30 | 3.51 | 9.25 | 45,319 |
| *Sales growth* | 14.14 | 12.84 | 30.15 | -84.36 | 133.38 | 45,319 |
| *Cash flow* | 7.71 | 5.70 | 7.56 | -3.88 | 57.81 | 45,319 |
| *Leverage* | 58.22 | 59.42 | 21.16 | 5.92 | 115.07 | 45,319 |
| *Collateral* | 31.26 | 29.46 | 15.43 | 4.15 | 76.67 | 45,319 |
| *Expdum* | 0.56 | 1.00 | 0.50 | 0.00 | 1.00 | 45,319 |

*Notes*: *NP* indicates the sale of new products, and *K*, total assets. *i* indexes firms and *t*, time. See the Appendix for complete definitions of all variables.

**Table 4.3: Testing for the presence of herding in Chinese firms' innovation activities**

| *Dependent variable:* | $\Delta\left(\frac{NP}{K}\right)_{i,t}$ | $\left(\frac{NP}{K}\right)_{i,t}$ |
|---|---|---|
| | (1) | (2) |
| $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ | 0.992$^{***}$ | |
| | (0.313) | |
| $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ | | 0.453$^{***}$ |
| | | (0.175) |
| *Size* | -19.518$^{*}$ | -7.906 |
| | (10.010) | (6.210) |
| *Sales growth* | 0.211$^{*}$ | 0.038 |
| | (0.116) | (0.076) |
| *Cash flow* | -2.539$^{***}$ | 1.215$^{*}$ |
| | (0.954) | (0.654) |
| *Leverage* | -0.043 | 0.260 |
| | (0.282) | (0.189) |
| *Collateral* | 0.016 | 0.032 |
| | (0.302) | (0.206) |
| *Expdum* | 25.879$^{*}$ | 21.837$^{**}$ |
| | (14.402) | (9.628) |
| *J(p-value)* | 0.195 | 0.195 |
| *m1* | -7.16 | -7.16 |
| *m2* | . | -0.89 |
| Observations | 7,367 | 19,706 |

*Notes: NP* indicates the sale of new products, and *K*, total assets. *i* indexes firms and *t*, time. We estimate all specifications using the first-difference GMM estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. Time dummies and industry dummies are included in all specifications. Instruments in all columns include two and deeper lags of all right hand side variables, time dummies, and industry dummies. The *J* statistic is a test of the over-identifying restrictions, distributed as chi-square under the null of instrument validity. *m1/m2* are tests for first-order/second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *m2* statistic is missing in the equation with $\Delta\left(\frac{NP}{K}\right)_{i,t}$ as dependent variable because of an insufficient number of time-series observations. See the Appendix for complete definitions of all variables. $^{***}$, $^{**}$ and $^{*}$ indicate significance at the 1%, 5% and 10% level, respectively.

**Table 4.4a: Testing for the presence of herding in Chinese firms' innovation activities differentiating firms on the basis of ownership, political affiliation, and size**

| *Dependent variable:* | $\Delta\left(\frac{NP}{K}\right)_{i,t}$ | | |
|---|---|---|---|
| | *Ownership-interactions* (1) | *Size-interactions* (2) | *Political affiliation-interactions* (3) |
| $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t} * CATEGORY1$ | 0.489<br>(0.464) | 0.186<br>(0.359) | -0.208<br>(0.599) |
| $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t} * CATEGORY2$ | 0.634<br>(0.600) | 0.685<br>(0.429) | 0.429<br>(0.359) |
| $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t} * CATEGORY3$ | 1.216***<br>(0.424) | 2.407***<br>(0.769) | 1.625***<br>(0.618) |
| *Size* | -20.858*<br>(10.893) | -8.653<br>(10.733) | -14.336<br>(11.061) |
| *Sales growth* | 0.199<br>(0.127) | 0.220*<br>(0.119) | 0.292**<br>(0.129) |
| *Cash flow* | -2.798***<br>(1.040) | -1.288<br>(1.053) | -1.780*<br>(1.036) |
| *Leverage* | -0.016<br>(0.289) | 0.169<br>(0.281) | -0.037<br>(0.283) |
| *Collateral* | 0.001<br>(0.311) | 0.283<br>(0.308) | -0.005<br>(0.298) |
| *Expdum* | 32.556**<br>(15.141) | 31.447**<br>(14.204) | 29.789**<br>(14.175) |
| *$H_0$:* Impact of $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\Delta\left(\frac{NP}{K}\right)_{i,t}$ same across *CATEGORY1* and *CATEGORY3* firm-years *(p-value)* | 0.163 | 0.005*** | 0.047** |
| *$H_0$:* Impact of $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\Delta\left(\frac{NP}{K}\right)_{i,t}$ same across *CATEGORY2* and *CATEGORY3* firm-years *(p-value)* | 0.443 | 0.070* | 0.109 |
| *$H_0$:* Impact of $\Delta\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\Delta\left(\frac{NP}{K}\right)_{i,t}$ same across *CATEGORY1* and *CATEGORY2* firm-years *(p-value)* | 0.847 | 0.330 | 0.274 |
| *J(p-value)* | 0.134 | 0.295 | 0.141 |
| *m1* | -5.20 | -5.21 | -5.34 |
| *m2* | . | . | . |
| Observations | 7,367 | 7,367 | 7,367 |

*Notes: NP* indicates the sale of new products, and *K*, total assets. *i* indexes firms and *t*, time. We estimate all specifications using the first-difference GMM estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. Time dummies and industry dummies are included in all specifications. Instruments in all columns include two and deeper lags of all right hand side variables, time dummies, and industry dummies. The *J* statistic is a test of the over-identifying restrictions, distributed as chi-square under the null of instrument validity. *m1/m2* are tests for first-order/second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *m2* statistics are missing in the equations using $\Delta\left(\frac{NP}{K}\right)_{i,t}$ as dependent variable because of an insufficient number of time-series observations. *CATEGORY1/CATEGORY2/CATEGORY3* indicate state-owned/foreign/private firms in column 1; high/medium/no political affiliation firms in column 2; and large/medium/small sized firms in column 3, respectively. See the Appendix for complete definitions of all variables. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

**Table 4.4b: Testing for the presence of herding in Chinese firms' innovation activities differentiating firms on the basis of ownership, political affiliation, and size**

| *Dependent variable:* | $\left(\frac{NP}{K}\right)_{i,t}$ | | |
|---|---|---|---|
| | *Ownership-interactions* | *Size-interactions* | *Political affiliation-interactions* |
| | (1) | (2) | (3) |
| $\overline{\left(\frac{NP}{K}\right)}_{-i,t} * CATEGORY1$ | -0.057<br>(0.226) | 0.014<br>(0.160) | 0.057<br>(0.406) |
| $\overline{\left(\frac{NP}{K}\right)}_{-i,t} * CATEGORY2$ | 0.637<br>(0.417) | $0.362^{**}$<br>(0.170) | $0.496^{**}$<br>(0.243) |
| $\overline{\left(\frac{NP}{K}\right)}_{-i,t} * CATEGORY3$ | $0.342^{*}$<br>(0.199) | $0.959^{***}$<br>(0.314) | $0.574^{***}$<br>(0.215) |
| *Size* | $-10.536^{**}$<br>(4.711) | -9.134<br>(5.599) | -7.323<br>(5.693) |
| *Sales growth* | -0.005<br>(0.056) | 0.034<br>(0.078) | 0.051<br>(0.069) |
| *Cash flow* | $0.804^{*}$<br>(0.433) | 0.205<br>(0.506) | $1.515^{***}$<br>(0.561) |
| *Leverage* | 0.227<br>(0.158) | 0.242<br>(0.166) | 0.278<br>(0.178) |
| *Collateral* | -0.073<br>(0.175) | 0.039<br>(0.194) | 0.093<br>(0.202) |
| *Expdum* | 10.926<br>(7.022) | $16.546^{*}$<br>(8.718) | $19.874^{**}$<br>(9.375) |
| *$H_0$:* Impact of $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\left(\frac{NP}{K}\right)_{i,t}$ same across *CATEGORY1* and *CATEGORY3* firm-years *(p-value)* | $0.079^{*}$ | $0.012^{**}$ | 0.245 |
| *$H_0$:* Impact of $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\left(\frac{NP}{K}\right)_{i,t}$ same across *CATEGORY2* and *CATEGORY3* firm-years *(p-value)* | 0.518 | $0.017^{**}$ | 0.772 |
| *$H_0$:* Impact of $\overline{\left(\frac{NP}{K}\right)}_{-i,t}$ on $\left(\frac{NP}{K}\right)_{i,t}$ same across *CATEGORY1* and *CATEGORY2* firm-years *(p-value)* | 0.116 | $0.083^{*}$ | 0.337 |
| *J(p-value)* | 0.630 | 0.625 | 0.192 |
| *m1* | -6.58 | -6.52 | -7.33 |
| *m2* | -0.63 | -0.82 | -0.76 |
| Observations | 19,706 | 19,706 | 19,706 |

*Notes: NP* indicates the sale of new products, and *K,* total assets. *i* indexes firms and *t*, time. We estimate all specifications using the first-difference GMM estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. Time dummies and industry dummies are included in all specifications. Instruments in all columns include two and deeper lags of all right hand side variables, time dummies, and industry dummies. The *J* statistic is a test of the over-identifying restrictions, distributed as chi-square under the null of instrument validity. *m1/m2* are tests for first-order/second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. *CATEGORY1/CATEGORY2/ CATEGORY3* indicate state-owned/foreign/private firms in column 1; high/medium/no political affiliation firms in column 2; and large/medium/small sized firms in column 3, respectively. See the Appendix for complete definitions of all variables. $^{***}$, $^{**}$ and $^{*}$ indicate significance at the 1%, 5% and 10% level, respectively.

## Table 4.5: Impact of innovation herding behavior on firm productivity

| *Dependent variables:* | *TFP* | *PROD* | *VAPW* |
|---|---|---|---|
| | (1) | (2) | (3) |
| $\left\lvert\left(\frac{NP}{K}\right)_{i,t}-\overline{\left(\frac{NP}{K}\right)}_{-i,t}\right\rvert$ | 0.034$^{***}$ | 0.009$^{***}$ | 0.002$^{***}$ |
| | (0.010) | (0.003) | (0.001) |
| *Size* | 7.579$^{***}$ | 1.921$^{***}$ | 0.491$^{***}$ |
| | (0.730) | (0.200) | (0.049) |
| *Sales growth* | -0.019$^{*}$ | 0.002 | -0.001 |
| | (0.010) | (0.002) | (0.001) |
| *Cash flow* | 0.572$^{***}$ | 0.080$^{***}$ | 0.033$^{***}$ |
| | (0.085) | (0.020) | (0.005) |
| *Leverage* | 0.162$^{***}$ | 0.023$^{***}$ | 0.008$^{***}$ |
| | (0.026) | (0.007) | (0.002) |
| *Collateral* | 0.027 | 0.005 | 0.003$^{*}$ |
| | (0.025) | (0.008) | (0.002) |
| *Expdum* | 1.000 | 0.266 | -0.031 |
| | (1.204) | (0.375) | (0.077) |
| *J(p-value)* | 0.000 | 0.000 | 0.000 |
| *m1* | -8.64 | -5.00 | -8.25 |
| *m2* | -1.69 | -0.27 | 0.57 |
| Observations | 19,706 | 19,706 | 19,706 |

*Notes*: Innovation herding is calculated as $\left\lvert\left(\frac{NP}{K}\right)_{i,t}-\overline{\left(\frac{NP}{K}\right)}_{-i,t}\right\rvert$, where $i$ indexes firms and $t$, time. *NP* indicates the sale of new products, and *K*, total assets. We estimate all specifications using the first-difference GMM estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. Time dummies and industry dummies are included in all specifications. Instruments in all columns include two and deeper lags of all right hand side variables, time dummies, and industry dummies. The *J* statistic is a test of the over-identifying restrictions, distributed as chi-square under the null of instrument validity. *m1/m2* are tests for first-order/second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. See the Appendix for complete definitions of all variables. $^{***}$, $^{**}$ and $^{*}$ indicate significance at the 1%, 5% and 10% level, respectively.

**Table 4.6: Impact of innovation herding behavior on corporate productivity: focusing on private firms, small firms, and firms with no political affiliation**

| *Dependent variables:* | *TFP* | *PROD* | *VAPW* |
| --- | --- | --- | --- |
| | (1) | (2) | (3) |
| ***Panel A: Private firms*** | | | |
| $\left\|\left(\frac{NP}{K}\right)_{i,t}-\overline{\left(\frac{NP}{K}\right)}_{-i,t}\right\|$ | 0.032*** | 0.011*** | 0.001** |
| | (0.009) | (0.004) | (0.001) |
| *J(p-value)* | 0.000 | 0.031 | 0.000 |
| *m1* | -8.09 | -4.27 | -7.22 |
| *m2* | -0.60 | 1.12 | 1.31 |
| Observations | 13,459 | 13,459 | 13,459 |
| ***Panel B: Firms with no political affiliation*** | | | |
| $\left\|\left(\frac{NP}{K}\right)_{i,t}-\overline{\left(\frac{NP}{K}\right)}_{-i,t}\right\|$ | 0.041*** | 0.020*** | 0.003*** |
| | (0.013) | (0.006) | (0.001) |
| *J(p-value)* | 0.000 | 0.176 | 0.103 |
| *m1* | -4.95 | -4.17 | -5.59 |
| *m2* | 0.57 | -0.58 | 1.54 |
| Observations | 8,604 | 8,604 | 8,604 |
| ***Panel C: Small firms*** | | | |
| $\left\|\left(\frac{NP}{K}\right)_{i,t}-\overline{\left(\frac{NP}{K}\right)}_{-i,t}\right\|$ | 0.013** | 0.015** | 0.002** |
| | (0.005) | (0.006) | (0.001) |
| *J(p-value)* | 0.273 | 0.784 | 0.430 |
| *m1* | -3.11 | -2.07 | -2.60 |
| *m2* | -0.08 | 0.52 | 1.19 |
| Observations | 3,832 | 3,832 | 3,832 |

*Notes*: Innovation herding is calculated as $\left|\left(\frac{NP}{K}\right)_{i,t}-\overline{\left(\frac{NP}{K}\right)}_{-i,t}\right|$, where *i* indexes firms and *t*, time. *NP* indicates the sale of new products, and *K*, total assets. We estimate all specifications using the first-difference GMM estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. Time dummies and industry dummiesare included in all specifications. Instruments in all columns are two and deeper lags of all right hand side variables, time dummies, and industry dummies. The *J* statistic is a test of the over-identifying restrictions, distributed as chi-square under the null of instrument validity. *m1/m2* are tests for first-order/second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. See the Appendix for complete definitions of all variables. $^{***}$, $^{**}$ and $^{*}$ indicate significance at the 1%, 5% and 10% level, respectively.

## Table 4.7: Robustness test: replacing average $\overline{\left(\frac{NP}{K}\right)}_{i,t}$ with median $\overline{\overline{\left(\frac{NP}{K}\right)}}_{i,t}$

| *Dependent variables:* | $\Delta\left(\frac{NP}{K}\right)_{i,t}$ | $\left(\frac{NP}{K}\right)_{i,t}$ | *TFP* | *PROD* | *VAPW* |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $\Delta\overline{\overline{\left(\frac{NP}{K}\right)}}_{-i,t}$ | 2.534$^{*}$<br>(1.539) | | | | |
| $\overline{\overline{\left(\frac{NP}{K}\right)}}_{-i,t}$ | | 1.164$^{***}$<br>(0.346) | | | |
| $\left\lvert\left(\frac{NP}{K}\right)_{i,t}-\overline{\overline{\left(\frac{NP}{K}\right)}}_{-i,t}\right\rvert$ | | | 0.036$^{***}$<br>0.009 | 0.015$^{***}$<br>0.004 | 0.002$^{***}$<br>0.001 |
| *Size* | -7.147<br>(9.974) | -16.162$^{**}$<br>(7.144) | 7.878$^{***}$<br>0.733 | 2.281$^{***}$<br>0.293 | 0.512$^{***}$<br>0.050 |
| *Sales growth* | 0.070<br>(0.136) | 0.106<br>(0.077) | -0.017$^{*}$<br>0.010 | 0.001<br>0.004 | -0.001<br>0.001 |
| *Cash flow* | -1.559<br>(0.975) | 0.958<br>(0.682) | 0.577$^{***}$<br>0.082 | 0.090$^{***}$<br>0.029 | 0.033$^{***}$<br>0.005 |
| *Leverage* | 0.072<br>(0.299) | 0.038<br>(0.187) | 0.158$^{***}$<br>0.025 | 0.028$^{***}$<br>0.009 | 0.008$^{***}$<br>0.002 |
| *Collateral* | -0.244<br>(0.321) | -0.114<br>(0.200) | 0.021<br>0.025 | 0.011<br>0.009 | 0.002<br>0.002 |
| *Expdum* | 41.173$^{***}$<br>(16.714) | 26.839$^{***}$<br>(9.644) | 0.889<br>1.164 | 0.367<br>0.440 | -0.042<br>0.076 |
| *J(p-value)* | 0.440 | 0.132 | 0.000 | 0.010 | 0.001 |
| *m1* | -5.36 | -7.27 | -8.38 | -5.41 | -8.22 |
| *m2* | . | -0.66 | -1.19 | 0.05 | 0.78 |
| Observations | 7,367 | 19,706 | 19,706 | 19,706 | 19,706 |

*Notes: NP* indicates the sale of new products, and *K*, total assets. *i* indexes firms and *t*, time. We estimate all specifications using the first-difference GMM estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. Time dummies and industry dummies are included in all specifications. Instruments in all columns are two and deeper lags of all right hand side variables, time dummies, and industry dummies. The *J* statistic is a test of the over-identifying restrictions, distributed as chi-square under the null of instrument validity. *m1/m2* are tests for first-order/second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *m2* statistic is missing in the equations using $\Delta\left(\frac{NP}{K}\right)_{i,t}$ as dependent variable because of an insufficient number of time-series data. See the Appendix for complete definitions of all variables. $^{***}$, $^{**}$ and $^{*}$ indicate significance at 1%, 5% and 10% level, respectively.

## Table 4.8: Robustness test: the impact of innovation herding at industry-level

| | *Industry-time level* | | | *Regional-industry-time level* | | |
|---|---|---|---|---|---|---|
| *Dep. variables:* | *TFP* | *PROD* | *VAPW* | *TFP* | *PROD* | *VAPW* |
| | (1) | (2) | (3) | (4) | (5) | (0036) |
| *Comove(NP)* | -7.327** | -5.367*** | -1.077*** | -4.165 | -3.055** | -0.649*** |
| | (3.709) | (1.255) | (0.220) | (3.880) | (1.373) | (0.224) |
| *Size* | 6.104*** | 1.759*** | 0.384*** | 6.355*** | 1.964*** | 0.422*** |
| | (0.541) | (0.239) | (0.039) | (0.560) | (0.238) | (0.039) |
| *Sales growth* | -0.026*** | 0.004 | -0.001 | -0.033*** | 0.002 | -0.001** |
| | (0.008) | (0.003) | (0.001) | (0.009) | (0.003) | (0.001) |
| *Cash flow* | 0.447*** | 0.070*** | 0.026*** | 0.456*** | 0.082*** | 0.029*** |
| | (0.058) | (0.022) | (0.004) | (0.063) | (0.022) | (0.004) |
| *Leverage* | 0.088*** | 0.012 | 0.004*** | 0.098*** | 0.013 | 0.005*** |
| | (0.018) | (0.007) | (0.001) | (0.020) | (0.008) | (0.001) |
| *Collateral* | -0.027 | -0.001 | 0.001 | -0.021 | -0.002 | 0.001 |
| | (0.019) | (0.008) | (0.001) | (0.021) | (0.008) | (0.001) |
| *Expdum* | 1.677* | 0.479*** | -0.013 | 2.087** | 0.714* | 0.027 |
| | (0.960) | (0.396) | (0.065) | (1.046) | (0.415) | (0.066) |
| *J(p-value)* | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| *m1* | -3.55 | -4.49 | -4.20 | -3.64 | -3.58 | -3.64 |
| *m2* | . | . | . | . | . | . |
| Observations | 7,367 | 7,367 | 7,367 | 7,367 | 7,367 | 7,367 |

*Notes: NP* indicates the sale of new products. We estimate all specifications using the first-difference GMM estimator. Heteroskedasticity-consistent standard errors are reported in parentheses. Time dummies and industry dummies are included in all specifications. Instruments in all columns are two and deeper lags of all right hand side variables, time dummies, and industry dummies. The *J* statistic is a test of the over-identifying restrictions, distributed as chi-square under the null of instrument validity. *m1/m2* are tests for first-order/second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The *m2* statistics are missing because of an insufficient number of time-series data. See the Appendix for complete definitions of all variables. ***, ** and * indicate significance at 1%, 5% and 10% level, respectively.

# Appendix

## Table 4.A1: Structure of unbalanced panel

Panel I.

| Year | *Number of observations* | *Percent* | *Cumulative* |
|---|---|---|---|
| *2000* | 2,929 | 6.46 | 6.46 |
| *2001* | 4,327 | 9.55 | 16.01 |
| *2002* | 5,300 | 11.69 | 27.71 |
| *2003* | 5,902 | 13.02 | 40.73 |
| *2005* | 9,012 | 19.89 | 60.61 |
| *2006* | 9,591 | 21.16 | 81.78 |
| *2007* | 8,258 | 18.22 | 100.00 |
| ***Total*** | 45,319 | 100.00 | |

Panel II.

| Number of obs. per firm | *Number of observations* | *Percent* | *Cumulative* |
|---|---|---|---|
| *1* | 8,430 | 18.60 | 18.60 |
| *2* | 9,282 | 20.48 | 39.08 |
| *3* | 8,676 | 19.14 | 58.23 |
| *4* | 6,076 | 13.41 | 71.63 |
| *5* | 5,185 | 11.44 | 83.08 |
| *6* | 4,506 | 9.94 | 93.02 |
| *7* | 3,164 | 6.98 | 100.00 |
| ***Total*** | 45,319 | 100.00 | |

## Table 4.A2: Descriptive statistics on sub-groups

| | *Ownership* | | | *Size* | | | *Political Affiliation* | | |
|---|---|---|---|---|---|---|---|---|---|
| | *CATEGORY1* | *CATEGORY2* | *CATEGORY3* | *CATEGORY1* | *CATEGORY2* | *CATEGORY3* | *CATEGORY1* | *CATEGORY2* | *CATEGORY3* |
| ***Innovation variable:*** | | | | | | | | | |
| *New products/Total assets* | 20.84 | 49.21 | 45.02 | 32.00 | 40.06 | 56.03 | 27.45 | 36.81 | 50.95 |
| ***Productivity variables:*** | | | | | | | | | |
| *TFP* | 6.20 | 7.55 | 5.89 | 10.49 | 5.43 | 2.94 | 7.89 | 5.78 | 5.79 |
| *PROD* | 1.67 | 3.74 | 2.82 | 3.61 | 2.69 | 2.13 | 2.42 | 2.42 | 3.19 |
| *VAPW* | 0.29 | 0.61 | 0.61 | 0.57 | 0.41 | 0.29 | 0.44 | 0.37 | 0.46 |
| ***Control variables:*** | | | | | | | | | |
| *Size* | 7.16 | 6.58 | 6.24 | 8.03 | 6.36 | 4.74 | 7.22 | 6.47 | 6.05 |
| *Sales growth* | 10.29 | 13.34 | 15.25 | 13.52 | 14.61 | 13.84 | 10.92 | 13.17 | 15.92 |
| *Cash flow* | 4.09 | 9.66 | 7.95 | 6.53 | 7.49 | 9.32 | 5.36 | 6.99 | 9.01 |
| *Leverage* | 65.24 | 47.87 | 58.81 | 58.92 | 58.45 | 57.05 | 59.01 | 60.16 | 56.34 |
| *Collateral* | 35.26 | 30.83 | 30.68 | 31.63 | 31.41 | 30.57 | 31.99 | 32.28 | 30.17 |
| *Expdum* | 0.49 | 0.80 | 0.54 | 0.69 | 0.54 | 0.47 | 0.54 | 0.53 | 0.60 |

*Notes*: *NP* indicates the sale of new products, and *K*, total assets. *i* indexes firms and *t*, time. See the Appendix for complete definitions of all variables. *CATEGORY1/CATEGORY2/ CATEGORY3* indicate state-owned/foreign/private firms in the column of *Ownership*; large/medium/small sized firms in the column of *Size*; and high/medium/no political affiliation firms in the column of *Political Affiliation*.

## Definitions of the variables used

*TFP*: total factor productivity calculated using the Levinsohn and Petrin (2003) method, applied separately to different industrial groups.

*VAPW*: ratio of value added (net income + income tax + wages + depreciation + interest payments) to total number of employees.

*PROD*: ratio of total real sales to total number of employees.

*Total assets*: sum of the firm's fixed and current assets, where fixed assets include tangible fixed assets, intangible fixed assets, and other fixed assets; and current assets include inventories, accounts receivable, and other current assets.

*New products (npa)*: ratio of new product sales to total assets.

*Size*: natural logarithm of totalreal assets.

*Cash flow*: ratio ofcash flow (net income plus depreciation) to total assets.

*Leverage*: ratio of total liabilities to total assets.

*Collateral:* ratio of tangible fixed assets to total assets.

*Expdum*: dummy variable equal to 1 if a firm reports a positive value of overseas sales, and 0 otherwise.

*Sales growth*: log-difference between total real sales in periods *t* and *t-1*.

*Assets growth*: log-difference between total real assets in periods *t* and *t-1*.

*Deflators*: all variables (except tangible fixed assets) are deflated using provincial ex-factory producer price indices taken from various issues of the China Statistical Yearbook. Tangible fixed assets are deflated using a deflator for fixed capital formation.

*Political affiliation (Lishu)*: *Lishu*=10, affiliated at central level; *Lishu*=20, affiliated at provincial level; *Lishu*=40: city or district level; *Lishu*=50, county level; *Lishu*=61, street level; *Lishu*=62, town level; *Lishu*=63, township level; *Lishu*=71, community level; *Lishu*=72, village level; *Lishu*=90, no political affiliation.

**Classification criteria:**

| | | |
|---|---|---|
| *Ownership (based on the majority average ownership shares)* | SOEs | At least 50% of all shares are state owned |
| | Foreign | At least 50% of all shares are foreign owned |
| | Private | At least 50% of all shares are privately owned |
| | Collective | At least 50% of all shares are collectively owned |
| *Size* | Small | If a firm's total real assets are in the lowest quartile of the distribution of total real assets of all firms belonging to the same industry in a given year |
| | Medium | If a firm's total real assets are in the second or third quartiles of the distribution of total real assets of all firms belonging to the same industry in a s given year |
| | Large | If a firm's total real assets are in the highest quartile of the distribution of total real assets of all firms belonging to the same industry in a given year |

| | | |
|---|---|---|
| *Political Affiliation* | No | If a firm has no political affiliation (*Lishu*=90) |
| | Medium | If a firm is affiliated at city or district level, or county level, or street level, or town level, or township level, or community level, or village level (*Lishu*>20 & *Lishu*<90) |
| | High | If a firm is affiliated at central or provincial level (*Lishu*<=20) |
| *Region* | East | If a firm is located in the coastal region, which includes the following provinces/autonomous regions/municipal cities: Beijing, Tianjin, Hebei, Liaoning, Jiangsu, Shanghai, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Guangxi |
| | Central | If a firm is located in the central region, which includes the following provinces/autonomous regions/municipal cities: Shanxi, Inner Mongolia, Anhui, Jiangxi, Heilongjiang, Jilin, Henan, Hubei, Hunan |
| | West | If a firm is located in the western region, which includes the following provinces/autonomous regions/municipal cities: Qinghai, Sichuan, Gansu, Yunnan, Xinjiang, Shaanxi, Guizhou, Chongqing, Ningxia, Tibet |

# Chapter 5

# To what extent do state and foreign ownership affect firms' innovation activities? Microeconometric evidence from China

Using data from 114,881 mainly unlisted Chinese firms over the period 2000−2007, we find a significant positive effect of joint ventures on innovation activity. Moreover, our results display an inverse U-shaped relationship between state ownership and product innovation. Foreign-affiliated firms, especially foreign-affiliated joint-venture firms, are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases. We also report strong evidence that, conditional on absorptive capacity, the relationship between foreign ownership and product innovation becomes positive for foreign-affiliated joint-venture firms.

## 5.1. Introduction

China's economy has undergone dramatic changes in the last 30 years. On the one hand, technological upgrades and global competition have emphasized the importance of innovation, and Chinese governments have made great progress towards building a favourable environment to facilitate innovation, through policy incentives, tax reductions, and other financial support. Still, innovation remains a key management challenge for Chinese governments, as well as for Chinese enterprises, since the latter have now become major participants in innovation activities.

On the other hand, China's economic reforms have led to significant changes in firms' ownership structure. This can be seen from the proliferation of increasingly diversified ownership forms, and by the fall in state ownership and the rise in foreign ownership (Jefferson and Singh, 1998). These changes may affect firms' innovation activities through issues of corporate governance, managerial discretion, resource allocation, risk distribution, and international cooperation (Li et al., 2008; Dong and Gou, 2010).

As China embarks upon its Eleventh Five-year Guidelines, State Owned Enterprises (SOEs) are being called on to take the lead in increasing China's capacity to innovate.[46] China's large and medium-sized SOEs have made significant gains in economic strength over the past 30 years, and have been a major driving force of the country's economic growth. Since China introduced reforms and open-door policies, independent innovation, encouraged by the Central Government, has played an increasingly important role in the transformation and development of

[46] Source: "The 11th Five-Year Plan", website: http://english.gov.cn/special/115y_index.htm

China's SOEs. State investors are therefore encouraged to take more responsibility in accelerating the development of new technologies, renovating traditional industries, and making new breakthroughs in key technologies. They are also incentivized to pay more attention to intellectual property rights and implement an intellectual property rights strategy that promotes sound interaction between technical innovation and intellectual property, encouraging some independently-developed core technologies, and play a leading role in industrial upgrades and structural optimization (Sheng and Zhao, 2012). However, China's SOEs has long been criticized as its inefficiencies, unfair competition, public displays of waste, in addition with corruption and bureaucratic problem (Lin et al., 2001). Recent news reported a number of issues from the results of a National Audit Office audit of ten SOEs, including inaccurate accounting, incomplete financial statements, illegal practices, which would result in poor management of investment decisions.[47] And these problems are more serious in purely SOEs, which attract deeply attention for Chinese government.

Although there has been some research on the relationship between foreign ownership and corporate performance (Greenaway et al., 2014), and some studies of the effect of FDI on innovation activities (Girma et al., 2008; Girma et al., 2009), empirical studies of the role of foreign ownership on evolving innovation activities at the firm-level are rare. As recently reported in The Economist,[48] China is gradually losing its appeal for foreign companies. Because of flagging growth and rising costs, in addition to increasing competition from domestic enterprises, foreign firms'

[47] Source: "China unveils audit results for state-owned enterprises", website: http://news.xinhuanet.com/english/ china/2013-05/10/c_132373725.htm
[48] Source: "China loses its allure", The Economist, website: http://www.economist.com/news/leaders/21595001-life-getting-tougher-foreign-companies-those-want-stay-will-have-adjust-china

business is getting tougher in China, and firms will have to adjust their investment strategies if they want to stay. Some foreign firms (for example: Best Buy, an American electronics retailer; Media Market, a German rival; and Yahoo!, an internet giant) have already left China. Some have given up trying to get it alone, and entered into joint ventures with domestic firms (see, for example, Tesco, a British food retailer). A very recent news released in Reuters reports that the Chinese state would no longer allow German car parts suppliers to operate their Chinese subsidiaries on their own, and instead only as part of joint ventures.[49] This action is believed to represent an attempt to strengthen cooperation in terms of know-how and innovation through political way.

In this chapter, we aim to investigate the relationship between firms' ownership and their innovation activities. China provides an ideal laboratory setting to study this issue. This is because China's innovation system has undergone considerable change in the past 30 years, and its innovation performance has improved remarkably. Furthermore, China's economic reforms have led to significant changes in ownership structure, which enables us to investigate firms' innovation activities across different ownership types and for different ownership levels.

Making use a panel of 114,881 mainly unlisted Chinese firms over the period 2000−2007, we investigate how joint ventures and state/foreign ownership affect corporate innovation activities. Based on a variety of specifications and a range of estimation methods, we find a significant positive effect of joint venture on innovation activity. Moreover, our results display an inverse U-shaped relationship

[49] Source: "German car parts suppliers asked to form JVs in China: Stuttgarter", Reuters, website: http://www.reuters.com/article/2014/08/25/us-autos-china-partnership-idUSKBN0GP0LV20140825

between state ownership and product innovation. For foreign-affiliated firms, especially for foreign-affiliated joint-venture firms, they are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases. We also report strong evidence that, conditional on absorptive capacity, the relationship between foreign ownership and product innovation becomes positive for foreign-affiliated joint-venture firms.

We contribute to existing literature in three ways. Primarily, for the first time in a Chinese context, we test the relationship between ownership and innovation at firm level, and we take into account the non-linear effect of ownership on innovation. Most of the studies examine the spillovers of FDI at industry level (Girma et al., 2008; Girma et al., 2009). Only a few papers in the literature have tested the state or foreign ownership on innovation on firm level (see for instance Choi et al., 2012; and Chen et al., 2014), but they only consider the linear effect. Second, we make use of a very large database, compiled by the Chinese National Bureau of Statistics (NBS) over the period 2000−2007. This database is made up of 114,881 mainly unlisted firms from 31 provinces or province-equivalent municipal cities, which make up to 563,386 firm-level observations. Unlike the study only focusing on the large and healthy listed firms with very strict regulations (for example, foreign firms still cannot directly list in China's stock market), our database includes a large proportion of small and young firms, and allow entry of new firms, and exit of exiting firms, also take the change of ownership into consideration.

The remainder of this chapter proceeds as follows: Section 5.2 reviews the literature on ownership and innovation. Section 5.3 puts forward our hypotheses. Section 5.4 introduces our database and presents summary statistics. Section 5.5 illustrates our models and estimation methodology. Section 5.6 describes our main empirical results. Section 5.7 presents robustness tests. Section 5.8 puts forward our conclusions.

## 5.2. Literature review

### 5.2.1. Joint ventures and firm innovation

Joint ventures (JVs) have become important in international business, especially in terms of innovation activities.[50] The nature of collaboration has shifted from peripheral interests to core functions of corporations, such as the generation, exchange, and/or adoption of new technologies (Caloghirou et al., 2003). Hladik (1994) and Tidd et al. (2001) summarize the potential benefits of JVs on firms' innovation activities. First, collaborative R&D agreements can spread the costs and risks of R&D between joint venture partners. Firms generally face financing constraints when they participate in innovation activities (Hall and Lerner, 2010; Brown et al., 2012). By sharing R&D expenses, JVs provide firms with financial resources and help them stay at the forefront of technology. Even if a firm is able to raise enough financing by itself, it still faces several risks, including the uncertainty of any expected R&D breakthrough, future consumer demands for a product, and the actions of competitors. With enough support, JVs allow firms to diversify their investment over several innovation projects and reduce these risks. Second, JVs have more ready access to technology and technical know-how. Each partner has a comparative advantage, and when the comparative advantages of the partners are

[50] According to OECD (1986), innovation is an important component of all the activities carried out by JVs. JVs are defined as activities "...in which the operations of two or more firms are partially, but not totally, functionally integrated in order to carry out activities in one or more of the following areas: (i) buying or selling operations; (ii) natural resource exploration, development and/or production operations; (iii) research and development operations; and, (iv) engineering and construction operations."

combined together, the technical capabilities of every single partner are exceeded. Third, JVs can provide access to domestic and international markets. Given the fixed costs of innovation, the larger the market, the higher the joint ventures' expected rate of return from R&D activities. Lastly, through innovative collaboration with potential competitors, JVs can not only reduce the number of competitors splitting the market, but also have the opportunity to develop common technical standards which form the basis for subsequent product design and development. This can ensure the JV firm keeps a favorable position relative to competition.

In an early empirical work, Link and Bauer (1989) find a positive relationship between cooperative R&D and firms' productivity in the US. Along the same line, Scott (1996) shows that cooperation appears to foster new research and expand the scope of the US firms' R&D horizon. Caloghirouet al. (2000) demonstrate that Europe has embarked on Framework Programmes for Research and Technological Development (FWP) since 1984, aimed at forcing European organizations to work together in cross-border partnership and created a sense of European "togetherness" in science and technology (S&T). In a broad survey of European companies, it is reported that JVs are beneficial for the development of new products and the improvement of technological and organizational capabilities. Adams and Marcu (2004) suggest that innovation is the primary motivation for research joint ventures. Instead of directly testing the effect of JVs on innovation, some empirical research has found a positive relationship between JVs and firms' performance (Benfratello and Sembenelli, 2002; Greenaway et al., 2014). Logically, better performing firms have more resources and higher capabilities to participate in innovation activities.

### 5.2.2. State ownership and firm innovation

Previous studies have obtained mixed results on the effect of state ownership on firms' innovation activities (Choi et al., 2011; Choi et al., 2012; Zhang et al., 2003; Shleifer, 1998). This is not surprising since state ownership influences innovation activities in two contrasting ways: positively, by playing a resource-rich role (accessing more resource with the support of the government) and representing an advantage in terms of political connections, but also negatively, in terms of agency costs and corruption problems.

Specifically, Choi et al. (2012) explain the positive effect of state ownership on innovation through resource dependence theory. This theory shows how organizations try to gain control over scarce resource. It was originally articulated by Pfeffer (1972), who propose that the resources which one organization needs for innovation are often in the hands of other organizations. From this perspective, the state can help controlled firms to access scarce technological resources, since they are generally resource-rich outsiders who possess specific properties, and can transcend many boundaries, bringing in the necessary resources for technological innovation. State-owned enterprises also benefit from financial resources and suffer little or not at all from financing constraints (Guariglia and Liu, 2014), which reduces firms' external dependencies and uncertainties in respect of resources, and therefore, promotes their innovation activities. Empirically, Chang et al. (2006) and Xu and Wang (1999) provide evidence that, in China, a high portion of state ownership is likely to positively impact technological innovation and R&D investment. In addition, Choi et al. (2011) demonstrate that governments stimulate firms' learning and innovation activities through an array of policy instruments.[51] Successful economies, such as South Korea and Taiwan, provide good examples of the state-led industrialization model, as well as government-driven technological development strategies (Amsden, 1992; Koo, 1987; Wade, 1990; Kim, 1997). State-owned enterprises or state investors can therefore benefit from these policy instruments due to their close relationship with the government.

However, some research has emphasized the negative aspects of state ownership on firm performance (Boardman and Vining, 1989; Vickers and Yarrow, 1991; Boycko et al., 1996; Dewenter and Malatesta, 2001). These authors argue that problems arise from a government's choices with regard to social and political policy objectives that go beyond profit maximization. Su et al. (2008) explain specifically that, in China, when the state is in a control position, it can appoint directors and managers who are sympathetic to the government's political objectives, such as preserving social stability or solving employment issues. Hart et al. (1997) and Shleifer (1998) argue that government agents have poor incentives to reduce costs or improve quality. Child (1994) and Child and Lu (1996) explain that the negative impact of government ownership on firm performance is caused by inefficient structures and a lack of managerial knowledge. Lin et al. (1998) demonstrate that the root of the SOE problem is the separation of ownership and control: the state cannot operate firms by itself and needs to delegate their control to the enterprises' managers. This separation may raise issues of incentive incompatibility and information asymmetry between managers and owners. In addition, corruption and

[51] Policy instruments include "the facilitation of R&D investments in strategic industries, the management of government-funded research institutes, the establishment of patent regulations and law, the import of advanced technology from foreign countries, and the launch of national strategic projects" (Choi et al., 2011, pp. 442). In 2006, the Chinese government put forward a policy called "The National Medium- and Long-Term Program of Science and Technology Development (2006-2020)", which aimed to strengthen China's scientific and technological (S&T) progress, and bring about an innovation-oriented society by 2020.

crony capitalism can develop through ‘unhealthy’ ties between government and businesses, and may play as a ‘grabber’ by demanding informal payments from firms, for example, bribery through issuing a license or circumventing laws and regulations, which limits firms’ incentive to innovate and lowers the returns of R&D (Lin et al., 2010).

### 5.2.3. Foreign ownership and firm innovation

Foreign investors (i.e. multinational corporations (MNCs) and financial institutions) join with domestic firms not merely through equity participation, but through a range of business and other activities, such as R&D (Douma et al., 2006). Cheung and Lin (2004) summarize several important channels through which domestic investors can benefit from the innovation activities of foreign firms in their host country. First, foreign partners provide domestic firms with advanced technologies, financial support, and managerial knowledge and resources (Srholec, 2009; Dachs and Ebersberger, 2009). Second, spillovers can take place through labor mobility whereby domestic firms “steal” skilled workers from foreign firms to obtain technological know-how (Fosfuri et al., 2011). Third, foreign technologies have a ‘demonstration effect’ which can inspire and stimulate domestic firms to participate in innovation. Moreover, since the products and technologies that foreign partners bring in have already been tested in foreign markets, the perceived risk of innovating along similar trajectories is relatively low for domestic firms. Finally, spillovers may take place vertically through supplier-customer relationships by means of technological know-how transfer, staff training, and so on, and enhance the innovation capability of local suppliers or customers.

A recent empirical study conducted by Guadalupe et al. (2012) uses Spanish firm-level data and find that foreign-acquired firms prompt a greater adoption of innovation activity. By investigating Japanese listed manufacturing firms, David et al. (2006) suggest that foreign ownership leads firms to engage in a more optimal level of R&D. Other empirical evidence reports that foreign-investment-related firms are more likely to introduce innovation than domestic firms in the US (Dunning and Narula, 1995), the UK (Frenz and Ietto-Gillies, 2007), Italy (Balcet and Evangelista, 2005), the Netherlands (Sadowski and Sadowski-Rasters, 2006), and other European countries (Falk, 2008; Srholec, 2009).

However, several studies have failed to find a significant positive effect or even observe the negative spillovers from foreign investment (Kinoshita, 2001; Knell and Srholec, 2005; Zhang and Rogers, 2009). Kokko (1994) explains that these findings, which contradict with respect to the positive effect of foreign investors, are generally caused by host country characteristics, for example, the educational level of the local labor force, local competition, and the requirements on the affiliates' operations. The support of local markets and access to local science and technology also determines the dispersion of R&D (Von Zedtwitz and Gassmann, 2002). Kuemmerle (1999) points out that the relative market size and relative strength of a country's science base determine the types of FDI, whether it is "Home-base-exploiting" or "Home-base-augmenting".[52] Beyond country characteristics, Cantwell and Mudambi (2005) find that the level of subsidiary R&D

[52] "Home-base-exploiting" describes a type of FDI in R&D where foreign investors exploit existing firm-specific advantages by establishing manufacturing facilities abroad to adapt existing products to local needs. "Home-base-augmenting" shows another type of FDI in R&D: that foreign firms augment knowledge by building up new knowledge production sites abroad and capturing externalities locally. "Home-base-exploiting" is preferred if a host country offers important market opportunities that a foreign firm seeks to convert into profit, while "Home-base-augmenting" is more probable if the size of a host country's knowledge base is large and the quality of this knowledge base is high (Kuemmerle, 1999).

also depends on multination enterprises' (MNEs) group-level and subsidiary-level factors.

In addition, Gertler et al. (2000) and Narula (2003) suggest that foreign-owned firms are likely to concentrate innovation activities in their home countries, while maintaining limited R&D and cooperation links to their host economy. According to OECD (1998), firms in developed countries spend less than 12 percent of total R&D expenditure outside their home sites. Lall (1992) argues that foreign firms are likely to transfer existing technologies to other countries, rather than develop new technologies abroad. Kuemmerle (1999) emphasizes that, whatever the type of FDI in R&D (either "Home-base-exploiting" or "Home-base-augmenting", as above) is undertaken, foreign firms' core technologies are generally located in firms' domestic headquarters or divisional headquarters.

Moreover, monopoly power is generally viewed as the main engine of technological progress, for reasons relating to the optimal scale for R&D and innovation, appropriability conditions, and the presence of financial constraints (Cohen and Levin, 1989; Symeonidis, 2001). However, foreign investment increases competition by raising the level of concentration in the host-country market (Aitken and Harrison, 1999), and thus trims down monopoly rents, therefore decreasing the incentive to innovate.

### 5.2.4. Absorptive capacity and firm innovation

Economic theory suggests that domestic firms need a certain level of technological capacity before they can benefit from foreign firms' stock of knowledge (Lapan and Bardhan, 1973). Cohen and Levinthal (1989) observe that domestic firms' own

R&D activities can boost firms' efficiency in an indirect way, by accelerating the assimilation of technologies generated in other countries. Cohen and Levinthal (1990) put forward the notion of absorptive capacity as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends". They emphasize that the ability of a firm to exploit external knowledge is a critical component of its innovative capabilities. Girma (2005) argues that absorptive capacity may result in different impact of FDI on productivity spillovers, which could either be negative, positive, or neutral. Initially, firms' productivity gains increase at an increasing rate of FDI with moderate absorptive capacity, but the magnitudes of FDI on productivity become less important or even negative if firms' technological capacity is too high or too low. Kostopoulos et al. (2011) offer evidence that absorptive capacity allows firms to identify more external knowledge inflows and add more positive value to innovation performance. Except for the positive impact on innovation, absorptive capacity also helps to reduce entry barriers into export markets, thus further boosting export performance (Harris and Li, 2009).

Existing literature has considered a multitude of activities to measure firms' or countries' absorptive capacity, including R&D expenditures and R&D intensity (Cohen and Levinthal, 1989; Cohen and Levinthal, 1990; Tsai, 2001; Griffith et al., 2000); employee skills, educated workers, technical personnel, or external scientists (Lund Vinding, 2006; Grimpe and Sofka, 2009; Cockburn and Henderson, 1998); investment in scientific and technical training (Mowery and Oxley, 1995); the firm's basic research activities (Rosenberg, 1990; Lane and Lubatkin, 1998; Dyer and Singh, 1998); inter-organizational trust and cultural compatibility between domestic and foreign parents (Lane et al., 2001); the economic policies that enforce competition among domestic firms (Mowery and Oxley, 1995); and the efficiency of the financial sector in host countries (Alfaro et al., 2004).

## 5.3. Hypotheses

### 5.3.1. Joint ventures and firms' innovation activities

In China, different investors generally have different advantages. Specifically, state investors and collective investors are likely to have a widespread knowledge of the Chinese markets and legal environment (Greenaway et al., 2014). They also have strong political connections (*Guanxi*) with central or local governments, which is often considered a key factor in determining firms' performance in China (Hsieh and Klenow, 2007). From the perspective of foreign investors, they bring in capital, modern technologies, and better corporate governance (through monitoring and market discipline, as well as managerial and international networking skills). Private or family investors are generally more creative, and have a higher degree of marketization, better incentive mechanisms, and fewer restrictions (Li et al., 2004).[53] Therefore, joint ventures (JVs) between two or more of these ownership groups can boost corporate innovation activities as each partner brings its comparative advantages to the firm. Based on the arguments above, we hypothesize that:

*Hypothesis 1: Joint ventures are more likely to undertake innovation activities relative to sole proprietorships.*

### 5.3.2. State ownership and firms' innovation activities

[53] See the explanations in footnote 15.

In transition economies such as China, the government still plays a key role in the process of innovation. With an increase of state ownership, firms can benefit more from political affiliation with the government. These benefits include access to technology, financial resources, highly skilled technicians, and regulatory and legal support. Moreover, at moderate levels of state ownership, no single shareholder group has complete influence, and the state owner is therefore forced to collaborate with other shareholder groups to negotiate their common interests instead of making arbitrary decisions (Su et al., 2008). Such mutual monitoring helps decrease the negative effects of government control on performance, such negative effects including low-level productive efficiency, non-maximization profit consideration, corruption and bureaucratic problem. As state ownership increases further, government control rises. Therefore, state owners no longer need to consult with other shareholder groups, and can appoint directors and managers sympathetic to the government's social and political goals. Under these circumstances, they may ignore projects with high profit or growth potential, such as innovation activities. In addition, corruption and crony capitalism problems are more significant when state ownership is high. Based on the arguments above, we hypothesize that:

*Hypothesis 2: There will be an inverse U-shaped relationship between state ownership and firms' innovation activities.*

### 5.3.3. Foreign ownership and firms' innovation activities

In China, foreign-affiliated firms still have comparative innovation advantages relative to domestic firms due to their advanced technologies, financial capacity, and managerial knowledge and resources. We therefore expect that foreign-affiliated firms are more innovative than purely domestic firms. However, we expect that this effect is particularly reflected in joint-venture. Guadalupe et al. (2012) point out that the fundamental objective for foreign firms is to increase firm productivity, no matter what activities they undertake internationally, including foreign innovation. Their aim is to get maximum profit with lowest risk and minimum cost. As proposed by Richards and Yang (2007), the level of environmental uncertainty in a host country has a negative impact on the share of foreign ownership in its international R&D. Although China has made great progress in reducing political, economic, and social uncertainty and FDI indeed has increased total fixed asset investment in the country (Chen et al., 1995), the Chinese market still faces a high degree of asymmetric information when developing innovation activities, because of its unsound property rights protections and poorly regulated patent legal system, as well as its weak shareholder protection and weak corporate governance systems. This puts foreign firms in an uncertain environment. Under these circumstances, foreign investors can collaborate with domestic firms and only invest a small amount of shares in joint ventures, especially when dealing with innovation projects with high risks and large costs.[54] Once the project succeeds, they will draw enormous profits, with only a minimal loss if the projects fail. With so little to lose and so much to gain, it is not surprising that firms with lower foreign ownership participation are more likely to undertake innovative activities.

As foreign shares increase, foreign investors have to commit more capital and therefore take relatively greater risks, increasing their uncertainty and decreasing their incentive to undertake innovation activities. When foreign ownership rises further to represent the majority of shareholders, foreign investors may enjoy fewer

[54] In some joint-venture firms, foreign investors may get some shares by only providing relevant technologies or patents but may have no capital investment.

advantages from domestic investors, including their widespread knowledge of the Chinese markets, and the legal, regulatory, and bureaucratic environments, as well as *Guanxi*[55] (Greenaway et al., 2014). All this may decrease their incentives to undertake innovative activities. In addition, foreign firms' innovation activities have been found constrained by their internal finance, which may restrict their investment in innovation (Guariglia and Liu, 2014). They may also face an increasing level of competition when the number of foreign investors in the market increases, which might hinder laggard firms to catch and will, in turn, tend to decrease their incentive to innovate. Moreover, Burkart et al. (1997) demonstrate a trade-off between monitoring and managerial initiative. With the rise of foreign ownership, foreign investors will increase their levels of monitoring and control power as it delegates a certain degree of control to management, but reduce their managerial initiative within a firm. From this perspective, firms with higher foreign ownership may have less initiative to innovate. In addition, firms that are fully (or almost fully) owned by foreign investors may locate their innovation activities mostly in their firms' headquarters. Their main tasks abroad are to redesign, customize, and adjust products, but not to undertake radical innovation. Based on this point, we expect less innovation activities in firms with a higher degree of foreign ownership.

Furthermore, in China, foreign firms include a large number of investors from Hong Kong, Macao and Taiwan (*HMT*). Greenaway et al. (2014) argue that investors from *HMT* are likely to be fundamentally different from investors from other parts of the world. On the one hand, HMT firms have a more limited ability to transfer technology to the domestic market (Huang, 2004; Buckley et al., 2007). On the other

[55] *Guanxi* can be portrayed as "the existence and development of interpersonal relationship in order to seek some specific privileges beyond usual norms, rules, and laws" (Wei and Youmin, 2001, pp. 295). In our research, we emphasize *Guanxi* on political connection with the government.

hand, “round-tripping” refers to the fact that some domestic firms go abroad and later re-invest back, registering as *HMT* firms to take advantage of favorable tax and regulatory treatment received by foreign investors (Huang, 2003; Xiao, 2004). In such cases, one would not necessarily expect firms with increasing *HMT* shares (viewed as foreign ownership) to undertake more innovation activities.

Due to the above, we hypothesize that:

*Hypothesis 3: Foreign-affiliated firms, especially foreign-affiliated joint-venture firms, are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases.*

### 5.3.4. The role of absorptive capacity

Based on a panel data set from China, Fu (2008) finds that the availability of absorptive capacity plays an important role on the relationship between FDI intensity and innovation efficiency. Specifically, the enhancement of local absorptive capacity can help to create effective assimilation of knowledge and technology spillovers from FDI. Similarly, Girma et al. (2009) find that FDI has a significant positive effect on SOEs’ innovation activities only when absorptive capacity is taken into account. They explain that SOEs with a greater absorptive capacity may be less likely to be “laggards” and may actually be able to increase their innovation activity in the presence of increasing competition from FDI. Liu and Buck (2007) incorporate absorptive capacity of local firms in Chinese high-tech industries into their analyses, and find that firms are likely to take advantage of external technology spillovers pending a certain level of absorptive capacity. These three studies focus on the effects of absorptive capacity at the industry or sector level, but, to the best of our knowledge, whether and how absorptive capacity works on the technology transfer from foreign investors to individual firms has not been studied. Dyer and Singh (1998) propose the concept of partner-specific absorptive capacity according to which "a firm has developed the ability to recognize and assimilate valuable knowledge from a particular alliance partner". This capacity allows collaborating firms to systematically identify and translate external knowledge inflow across organizational boundaries, and achieve superior innovation. More specifically, with absorptive capacity, domestic investors can recognize the value of new, external information or technology, learn and assimilate it from their foreign partners, and finally create their own innovation and apply it to commercial ends. Therefore, we believe that, with foreign shares increasing in a collaborating firm, domestic investors with a certain level of absorptive capacity will recognize and assimilate more valuable know-how and technology from foreign investors, and eventually promote innovation activities. Based on the above reasons, we therefore hypothesize that:

*Hypothesis 4: Conditional on absorptive capacity, the relationship between foreign ownership and firms' innovative activities will turn from negative to positive.*

## 5.4. Data and summary statistics

### 5.4.1. Data

The data we used in this chapter is similar as we used in Chapter 3. We also follow the similar process and criteria to clean the data. After the above adjustments, our final panel data set includes 563,368 firm-level observations, covering 114,881 mainly unlisted firms over the period 2000−2007.[56] The sample is unbalanced: the structure of the panel is shown in Table 5.A1 in Appendix. The number of observations ranges from a minimum of 49,222 in 2000 to a maximum of 98,468 in 2003. Similar as in Chapter 3, we define innovation activities as the ratio of a firm's sales of new products to total sales.[57]

The NBS dataset contains a continuous measure of ownership, based on the fraction of paid-in-capital contributed by six types of investor: the state; foreign investors (excluding those from Hong Kong, Macao and Taiwan); investors from Hong Kong, Macao and Taiwan; legal entities; individuals; and collective investors.[58] Our state ownership variable is taken as the share of a firm's capital paid in by all state investors, while the foreign ownership variable is calculated by the share of the firm's capital paid in by all foreign investors, including those from Hong Kong, Macao and Taiwan.

### 5.4.2. Summary statistics

In Table 5.1, we divide our observations into four categories on the basis of the share of capital paid in by state investors (Panel A). Our first category in Panel A contains those firm-years with no state participation, which make up 90.39% of our sample. Our second category in Panel A encompassed those observations with a share of

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[56] It should be noted that listed firms are included in our dataset. However, they represent only a very small proportion of our sample: in 2007, for example, there were only 1,550 listed firms out a total of 93,552 firms. In addition, it is difficult to track these firms as their legal identification numbers are changed when they go public.

[57] All our results were robust to focusing on the ratio of sales of new products to total assets (see Table 5.1).

[58] We classify ownership based on the fraction of capital paid in by various agents in every year, rather than by registration codes. One reason for this choice is that there are often substantial delays in updating firms' registration codes, which make them unreliable. Another reason is that firms might have an incentive to falsely register as foreign firms, in order to take advantage of the benefits granted to these firms.

state capital which is positive but lower than 50% (2.50% of our sample). Our third category in Panel A includes observations with a state share equal to or higher than 50% but lower than 100% (2.13% of our sample). Our final category displays firms than are 100% state owned, which make up 4.99% of our sample. Similarly, we divide our observations into four categories on the basis of the share of capital paid in by foreign investors using the same thresholds: 0%, 0%−50%, 50%−100%, 100% (Panel B). Each category makes up 74.27%, 7.26%, 4.97%, and 13.51% of our sample, respectively. We also make finer classifications based on every 25% of the share of capital paid in by state investors (Panel C) and foreign investors (Panel D).

[Insert Table 5.1 here]

Our analysis focuses on the following measures of innovation activity: *dnp* (a dummy variable, which equals to 1 if a firm has new product sales, and 0 otherwise); *nps* (the new product sales to total sales ratio). We also provide an alternative measure of innovation, *npa* (the new product sales to total assets) for robustness. This variable was used in Guariglia and Liu (2014).

Table 5.1 presents summary statistics about the behavior of our innovation variables for different categories of ownership. In Panel A, we observe that *dnp*, *nps*, and *npa* all increase with the degree of state ownership, but decline for those observations that are 100% state owned. This suggests that firms with state capital are more likely to innovate and invest more in innovation activities than firms without any state capital. This may reflect the fact that state investors bring in attributes essential to innovation activities. Specifically, state investors take advantage of superior financing accessibility, thereby suffering less or not at all from financial constraints (Guariglia and Liu, 2014). However, product innovation in purely state owned firms (column 4) is relatively smaller than in state joint-venture firms (columns 2 and 3). This indicates that, firms' product innovation firstly increase with the rise of state ownership, but then decrease after state ownership going up still further, which presents an inverse U-shaped relationship between state ownership and firms' innovation activities. This result is in line with our Hypothesis 2. Meanwhile, it also indicates that join venture firms are more likely to undertake innovation activities, which provide evidence for our Hypothesis 1.

In Panel B, we can observe that *dnp*, *nps*, and *npa* all decrease with the degree of foreign ownership, but their average values in foreign affiliated joint-ventures (columns 2 and 3) are larger than in purely domestic firms (column 1), and also larger than purely foreign firms (column 4). This trend indicates that product innovation will decrease with an increase of foreign ownership, but that product innovation in foreign-affiliated firms, at least in foreign-affiliated joint-venture firms is, on average, greater than in purely domestic firms. This provides evidence for our Hypothesis 2.

## 5.5. Model and methodology

### 5.5.1. Baseline models

In order to test our hypotheses, we initially estimate the following regression:

$$\begin{aligned} Innovation_{i,t} = {} & \beta_0 + \beta_1 Innovation_{i,t-1} + \beta_2 JV_{i,t-1} + \beta_3 Size_{i,t-1} + \beta_4 Leverage_{i,t-1} \\ & + \beta_5 Collateral_{i,t-1} + \beta_6 Expdum_{i,t-1} + \beta_7 Compete_{i,t} + \beta_8 Compete^2{}_{i,t} \\ & + \beta_9 Tech\_gap_{i,t} + v_i + d_t + \varepsilon_{i,t} \qquad (5.1) \end{aligned}$$

where the subscript $i$ indicates firms, and $t$, time. The dependent variable $Innovation_{i,t}$ represents innovation activities. When examining the *probability* of $Innovation_{i,t}$, the dependent variable is a binary variable taking a value of one if the firm has positive new product sales, and zero otherwise. When focusing on the determinants of the *amount* of $Innovation_{i,t}$, the dependent variable is a censored variable which is equal to zero if the firm does not have new product sales, and takes the value of the actual new product sales to total sales ratio, otherwise.

The independent variables in Equation (5.1) include proxies aimed at testing the effect of joint-ventures on innovation, as well as some control variables. Specifically, $JV_{i,t}$ is equal to 1 if a firm owned by two or more agents, and 0 otherwise. If joint-ventures enhance firms' innovation activities, we expect that $\beta_2 > 0$. The other regressors in Equation (5.1) are informed by the finance literature (e.g. Choi et al., 2011). $Size_{i,t-1}$ is defined as the lagged value of the natural logarithm of real total sales.[59] Large firms are more likely to be innovative because they have more financial and technical capabilities, economies of scope so as to spread the risk of failure and absorb the costs of innovation, the ability to establish and maintain scientific facilities, the resources to hire professional and skilled workers, and the ability to raise capital and market an innovation (Damanpour, 2010). Guariglia and Liu (2014) find that large firms are less likely to be subject to financial constraints, which should facilitate their tendency to innovate. We therefore expect a positive coefficient on firm size. $Leverage_{i,t-1}$ is the lagged value of the ratio of total liabilities to total assets. On the one hand, firms with a high debt ratio might decrease their innovation activities due to concerns over bankruptcy risk. On the other hand, although debt finance is not a favorite source of financing for innovation-intensive

[59] All our results are robust to using the natural logarithm of real total assets to measure firm size.

firms in the U.S. (Brown et al. 2009, Brown et al. 2012), it plays an important role for Chinese firms, especially for state-owned firms who can easily access loans from banks.[60] We therefore remain agnostic about the sign of the coefficient associate with the leverage ratio. $Collateral_{i,t-1}$ is the lagged value of the ratio of tangible to total assets, which is expected to negatively affect innovation. Hovakimian (2009) argues in fact that firms with high tangibility are more likely to operate in industries with low growth potential, and could therefore display lower R&D investment and less new product output. $Expdum_{i,t-1}$ is an export dummy, which is equal to 1 if a firm exports, and 0 otherwise. Consistent with widespread evidence that innovation and exports are positively correlated (Girma et al., 2009; Pla-Barber & Alegre, 2007), we would expect a positive sign on $Expdum_{i,t-1}$.

We also take the influence of competition into consideration. Aghion et al. (2002) find an inverted U-shaped relationship between product market competition (measured by the price cost margin) and innovation. They explain that the positive "escape competition effect" dominates when the competition level is low, whereas the negative "Schumpeterian effect" dominates when competition level is high.[61] We therefore expect similar results in our estimations. Tingvall and Poldahl (2006) show that this inverted U-shaped relation is only supported by the Herfindahl index, but not by the price cost margin. They also point out the Herfindahl index is more appropriate when an economy is large (i.e. when the domestic market is the main market). Considering their results and the characteristics of the Chinese market, we calculate the Herfindahl index (*HI*) at the 2-digit industry level, as follows:

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[60] Unlike the U.S., most Chinese firms generally do not issue equity. In addition, more than 95% of the firms covered in our dataset are unlisted.

[61] The "escape competition effect" means that more competition induces neck-and-neck firms to innovate in order to escape competition. The "Schumpeterian effect" indicates that more competition may reduce innovation as the laggard's reward to catching up with the technological leader may fall, which is more typical in less neck-and-neck, or more "unleveled" industries (Aghion et al., 2002).

$$HI = \left\{ \sum_{i=1}^{N} s_{i,t}^{2} \right\}, \; where \; s_{i,t} = \frac{sales_{i,t}}{\sum_{i=1}^{N} sales_{i,t}}$$

where the subscript *i* indicates firms, and *t*, time. *HI* measures firm size in relation to the industry and thereby indicates the amount of competition. Its value ranges from 0 (many competitors and/or many equally distributed market shares) to 1 (a single monopolistic producer with no competitors). In order to understand the relationship between competition and innovation more directly, we use the reverse Herfindahl concentration index (one minus the Herfindahl index) to measure industry competitive intensity, i.e. we define the following variable: $Compete = 1 - HI$, as in Ju and Zhao (2009). The higher the value of *Compete*, the more competitive the industry. We also include its squared term, $Compete^2$, to capture the non-linearity, as suggested by Aghion et al. (2002).

Furthermore, we consider the effect of technology gap on innovation. As originally proposed by Findlay (1978) and confirmed by several other works, including Wang and Blomström (1992), Sjöholm (1999), and more recently, Jabbour and Mucchielli (2007) and Imbriani et al. (2014), the technology gap has a positive impact on the spillovers between domestic firms and multinational enterprises. They explain that a firm distant from the technology frontier has a larger backlog of established knowledge to absorb than a leading-edge firm. According to the definition in Tingvall and Poldahl (2006), we calculate the technology gap (*Tech_gap*) as follows:

$$Tech\_gap_{i,t} = \frac{TFP_{j,m,t}^{max} - TFP_{i,t}}{TFP_{i,t}}, \text{ where } j = leading \; firm$$

The subscript *i* indicates firms; and *t*, time. $TFP_{i,t}$ represents total factor productivity for the $i$th firms in year $t$.[62] $TFP^{max}_{j,m,t}$ denotes the maximum TFP for the leading firm $j$ in the $m$th industry in year $t$. ($TFP^{max}_{j,m,t} - TFP_{i,t}$) therefore indicates the distance to the technology frontier for the $i$th firms in year $t$. We expect a positive coefficient of *Tech_gap* on innovation.

To better understand the nature of the relationship between state/foreign ownership and firm innovation activities, we then estimate the following variant of Equation (5.2), which replaces the JV dummy with the actual percentage of the firm's capital paid in by state/foreign investors, *Statecap/Foreigncap*, respectively:

$$\begin{aligned} Innovation_{i,t} = {} & \beta_0 + \beta_1 Innovation_{i,t-1} + \beta_2 Statecap_{i,t-1} + \beta_2 Statecap^2_{i,t-1} \\ & + \beta_3 Foreigncap_{i,t-1} + \beta_2 Foreigncap^2_{i,t-1} + \beta_4 Size_{i,t-1} \\ & + \beta_5 Leverage_{i,t-1} + \beta_6 Collateral_{i,t-1} + \beta_7 Expdum_{i,t-1} \\ & + \beta_8 Compete_{i,t} + \beta_9 Compete^2{}_{i,t} + \beta_{10} Tech\_gap_{i,t} \\ & + \beta_{11} Privatecap_{i,t-1} + \beta_2 Privatecap^2_{i,t-1} + v_i + v_j + d_t + \varepsilon_{i,t} \qquad (5.2) \end{aligned}$$

where the subscript $i$ indicates firms; and $t$, time. Considering the large literature on the effects of privatization on corporate performance, which further affects innovation, we also include *Privatecap* (the percentage of the firm's total capital paid by the private investors) and its squared term $Privatecap^2$ in all specifications. Other control variables are the same as defined in Equation (5.1).

In order to test whether the impact of foreign ownership on innovation is different depending on absorptive capacity, we then estimate Equation (5.3), which interacts *Foreigncap* with an absorptive capacity dummy, as follows:

[62] TFP estimates based on the Levinsohn and Petrin (2003) method can be obtained in STATA by using the *levpet* command.

$$
\begin{aligned}
Innovation_{i,t} = {} & \beta_0 + \beta_1 Innovation_{i,t-1} + \beta_2 Statecap_{i,t-1} + \beta_3 Foreigncap_{i,t-1} \\
& * High\_AC + \beta_4 Foreigncap_{i,t-1} * Low\_AC + \beta_5 Size_{i,t-1} \\
& + \beta_6 Leverage_{i,t-1} + \beta_7 Collateral_{i,t-1} + \beta_8 Expdum_{i,t-1} \\
& + \beta_9 Compete_{i,t} + \beta_{10} Compete^2{}_{i,t} + \beta_{11} Tech\_gap_{i,t} \\
& + \beta_{12} Privatecap_{i,t-1} + v_i + d_t + \varepsilon_{i,t} \qquad (5.3)
\end{aligned}
$$

where the subscript *i* indicates firms; and *t*, time. *High_AC (Low_AC)* are dummy variables equals to 1 if a firm has a high (low) level of absorptive capacity, and 0 otherwise. Specifically, we follow the definition in Girma et al. (2009),[63] which *High_AC (Low_AC)* equals to 1 if a firm has R&D investment (or not) or has past experience in product innovation (or not); and 0 otherwise.

Cohen and Levinthal (1990) argue that firms conducting their own R&D are better able to use externally available information,[64] which implies that absorptive capacity may be created as a byproduct of a firm's R&D investment. They also suggest that prior related knowledge is important for firms to assimilate and use new knowledge. Research on memory development suggests that accumulated prior knowledge increases both the ability to put new knowledge into memory, and the ability to recall and use it. Lane et al. (2001) also point out that managerial, marketing, and manufacturing knowledge and skills are all developed through past experience, which have a positive impact on learning from foreign parents. Fu (2008) highlights that it is necessary for a firm to have a certain level of R&D intensity before it can benefit from FDI-generated externalities. According to the literature discussed above and considering the information available from our data, we

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[63] In their paper, they consider absorptive capacity by using the following four indicators: past experience in product innovation, R&D activity, labor training, and exporting. For labor training measure, we do not have this data so we cannot test for it. For exporting measure, more than 80% foreign firms in our sample are exporting, which has very limit impact when differentiating them separately. Therefore, we use the first two indicators (past experience in product innovation, and R&D activity) to measure firms' absorptive capacity.

[64] Also see Tilton (1971), Allen (1977), and Cohen and Levinthal (1989).

therefore take R&D activity and past experience in product innovation as indicators of absorptive capacity.[65] Other control variables are the same as defined in Equation (5.1) and Equation (5.2).

The error term in Equation (5.1), (5.2), and (5.3) is made up of four components. $v_i$ denotes a firm-specific effect; $d_t$ represents time-specific effect, which we take into account by including time dummies in our regressions capturing business cycle effects; $v_j$ is an industry-specific effect, which we control for by including industry dummies. Finally, $\varepsilon_{i,t}$ is an idiosyncratic error term.[66]

### 5.5.2. Estimation methodology

We first estimate a pooled probit model to examine the impact of JVs or state/foreign ownership on the probability of the firm to undertake innovation activities. We then use a pooled tobit model to test the effect of these variables on the amount of innovation activities. [67] To control for the potential endogeneity of our regressors, all variables except *Compete*, *Compete*$^2$, and *Tech_gap*, are lagged once in our regression, with the aim to alleviate simultaneity bias.[68] As a robustness test, we also estimate our equations using Instrumental Variable (IV) Probit and Tobit models.[69]

[65] These two indicators are also used in Girma et al. (2009).
[66] All our results were robust to including regional dummies, as well as to including industry and time-industry interactions.
[67] Our results are robust to using random-effects probit and tobit estimators. We prefer the pooled probit and tobit models with cluster-robust standard errors to the random-effects estimators owing to their computational advantages: for large samples, computational time is in fact an issue for random-effects probit and tobit models, because they use full 'random effects' with a high number of covariates (Wooldridge, 2008).
[68] We do not lag *Compete*, *Compete*$^2$, and *Tech_gap* as they are calculated at industry level, and less likely to affect firms' activities. However, the results were still robust when we lag them once.
[69] See Table 5.6.

## 5.6. Results and discussion

Table 5.2 shows the estimates of Equation (5.1). Specifically, the results in column 1 are predicated on our baseline static model without including the lagged dependent variable and without considering the effects of competition and technology gap. The marginal effects indicate that increasing the probability of the firm being a joint ventures by 0.1, or 10 percentage points, would increase the probability of selling new products by 0.0018, or about 0.18 percentage points. The estimation in column 2 improves our baseline model by adding the lagged dependent variable into consideration, calling as dynamic model. We observe that the coefficient on JV is also positive and significant, but the marginal effect is smaller (a 10-percentage point rise in the probability of being a joint venture increases the probability of innovation by 0.05 percentage points). The positive effect of joint ventures is also present in column 3, when we consider the competition and technology gap effects. This evidence supports our first hypothesis.

[Insert Table 5.2 here]

Focusing on the control variables, the size term displays a significantly positive relationship with innovation activity. This is in line with the findings of Choi et al. (2012). In the presence of a 10-percentage point rise in size, the probability of innovation increases by 0.13 percentage points. This is because large firms generally have several advantages, such as more financial resources, more technical capabilities, and a greater ability to spread the risk of failure, compared with small firms when participating in innovation (Damanpour, 2010). The coefficient on leverage is significant and positive, due to the important role of external finance on innovation. Specifically, a 10-percentage point raises in leverage increases the probability of innovation by 0.07 percentage points. In line with our expectations, exports have a positive effect on innovation. With a 10-percentage point increase in exports, the probability of innovation rises by 0.1 percentage points. Cheung (2010) explains that exports provide a channel to attract FDI and strength spillover effects on innovation performance. We also find an inverted U-shaped relationship between competition and innovation (with a positive coefficient on *Compete*, and a negative coefficient on $Compete^2$, both of which are significant), which is in line with the findings in Aghion et al. (2002) and Tingvall and Poldahl (2006). This indicates that, in the case of low competition, the leading firms are in a monopolistic position and therefore have a lower incentive to innovate. Followers have therefore an opportunity to catch up and will increase their innovation. However, when market competition is high, leading firms will invest relatively more in innovation to retain their strong positions, which makes it difficult for lagging firms to catch up and will, in turn, decrease their incentive to innovate. The coefficient on the technology gap is consistent with our prediction, as it is positive and significant. This indicates that a firm that is distant from the technology frontier has a higher incentive to innovate.

We then estimate Equation (5.1) using a pooled tobit mode to explore the effect of joint ventures on the actual new product sales to total sales ratio. The results are shown in columns 4−6 in Table 5.2. In line with the findings of the probit model, a higher probability of being a joint ventures is associated with a higher level of product innovation. The marginal effects suggest that a 10-percentage point rise in the probability of being a joint ventures increases the new products sales to total sales ratio by 0.26 percentage points in the static model (column 4), and by and 0.13 points in the dynamic models (column 5 and 6). This once again provides evidence in support of our Hypothesis 1. The results for the other control variables are consistent with the results in the probit model.

Table 5.3a reports regression results for Equation (5.2), which tests the relationship between state/foreign ownership and firm innovation activities based on the pooled probit model. All specifications are estimated as dynamic models and include market competition and technology gap. Focusing on column 1, we observe that the coefficient on *Statecap* is positive and significant, while that on *Foreigncap* is negative and significant. In order to test the non-linear effect of state/foreign ownership on innovation, we include the squared term $Statecap^2$ and $Foreigncap^2$. We find that $Statecap^2$ is negatively associated with product innovation, whilst the coefficient on *Statecap* is still positive and significant (see column 2). This provides evidence that there is an inverse U-shaped relationship between state ownership and product innovation, and is consistent with our Hypothesis 2. The average turn point is around 70%.[70] Specifically, when state ownership rises to a relatively low or moderate level (lower than 70%), firms increasingly build up their political affiliation with the government and therefore enjoy several benefits, such as access to scarce technological resources, financial resources, highly skilled technicians, regulation advantages and legal support Yet, if state ownership increases beyond a certain threshold (more than 70%), the power of state control rises over a firm's board. In this case, state investors can appoint directors and managers who are sympathetic to the government's social and political goals. These individuals may ignore projects with high profit potential, such as innovation activities. In addition, firms with high levels of state ownership generally experience several other problems, such as corruption and crony capitalism, which may further affect firms'

[70] This turning point is calculated as - (0.798/(2*(-0.566))).

investment decisions.

[Insert Table 5.3a here]

We also add the squared term $Foreigncap^2$ to our Equation (5.2) to consider the non-linear effect of foreign ownership. The results are also shown in column 2 in Table 5.3a. Although the coefficient for $Foreigncap^2$ is negative and significant, *Foreigncap* does not have a precisely determined coefficient. However, as there is a positive sign on *Foreigncap*, we believe product innovation will increase as the rising of foreign ownership, but this trend is not significant. Then we test whether there is a break for different level of foreign ownership. Following this idea, we add *DF* (a dummy variable, which equals to 1 if a firm has foreign ownership, and 0 otherwise) into Equation (5.2) to test whether there is significant difference between foreign-affiliated firms and purely domestic firms, and re-examine the impact of foreign ownership on product innovation in foreign-affiliated firms. The results based on the pooled probit regression are present in column 3 in Table 5.3a. We observe that the coefficient on *DF* is positive and significant, which indicate that foreign-affiliated firms are more likely to innovation than purely domestic firms. Meanwhile, the coefficient on *Foreigncap* is negative and significant, which means foreign ownership has a negative impact on product innovation in foreign-affiliated firms. This is consistent with the argument of Liu and Buck (2007), who observe that inward FDI may negatively affect the innovation activities or productivity of local firms by monopolising markets, drawing demand from local firms and substituting local suppliers with foreign ones. We then add the squared term $Foreigncap^2$ for consideration, and its coefficient is not significant (see column 4). Moreover, taking into account the difference between joint-venture firms and fully owned firms, we divide *DF* into two parts: *DF0100* (a dummy variable, which equals to 1 if a firm has positive foreign ownership but less than 100%, and 0 otherwise), and *DF100* (a dummy variable, which equals to 1 if a firm 100% owned by foreign ownership, and 0 otherwise). The results are present in column 5 in Table 5.3a. We observe that the coefficient for *DF0100* is positive and significant, but insignificant for *DF100*. This indicates that foreign-affiliated joint venture firms are more likely to undertake innovation activities, but not for fully foreign owned firms, which provide further evidence for our Hypothesis 1. The coefficient for $Foreigncap^2$ is still insignificant in column 6. These results are in line with our third hypothesis that foreign-affiliated firms, especially foreign-affiliated joint-venture firms, are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases.[71]

Similar results are obtained in Table 5.3b, which reports Tobit estimates for the ratio of new product sales to total sales. All the results for other control variables are consistent with the findings presented in Table 5.2. In addition, we note that *Privatecap* have a significantly positive impact on innovation, which is in line with the findings of Ayyagari et al. (2012), who report that ownership by families and individuals is associated with higher firm innovation. Guariglia and Liu (2014) also show evidence of a higher new products sales to total sales ratio for private firms in their summary statistics, indicating that private firms have a strong enthusiasm to participate in innovation activities. Similarly, we consider the non-linear effect of private ownership, and find the coefficient on $Privatecap^2$ to be negative and significant, which indicates that private ownership also has a negative impact on product innovation if it increases beyond a certain threshold.

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[71] There are not serious correlations among independent variables through Pairwise Correlation tests. Results are available from the author upon request.

[Insert Table 5.3b here]

In order to capture the effects of absorptive capacity on the relationship between foreign ownership and innovation, we expend the model by including the interaction terms of foreign ownership and absorptive capacity. The regression results are shown in Table 5.4.[72] We find that state ownership still has an inverse U-shaped relationship with product innovation, but that the coefficient for foreign ownership become positive when it is interacted with *High_AC*, yet remained negative when it is interacted with *Low_AC*.[73] We also report *p*-values associated with *F*-tests aimed at assessing whether the impact of *Foreigncap* on *dnp*/*npa* is equal across various groups of firms-years. The results reject the hypothesis that there is no difference between firms with high absorptive capacity and those with low absorptive capacity. This evidence provides strong support for the proposition of the important role of absorptive capacity in the assimilation of technology spillover from foreign investors. The coefficients associated with other control variables are similar to those reported in previous specifications.

[Insert Table 5.4 here]

## 5.7. Robustness tests

### 5.7.1. Replacing JV with a measure of ownership diversity

[72] The observations in Table 5.4 are smaller than in previous tables, because we examine the effect of absorptive capacity only in foreign-affiliated joint-venture firms. Absorptive capacity works in fact within a firm through reorganization and assimilation of valuable knowledge from foreign partners and transfer technology or know-how to domestic partners. It is therefore less like to happen in purely domestic firms or fully foreign-owned firms. And we only perform the results based on tobit model. As discussed in Ai and Norton (2003), the estimation on interaction term in probit models may cause biased.

[73] The results are robust if we add the squared of foreign ownership (*Foreigncap*$^2$), and the coefficient on *Foreigncap*$^2$ is not significant.

We use ownership type diversity as an alternative measure of joint venture. This measure is widely used (e.g. Chen et al. 2014; Zhou and Li, 2008) to calculate ownership diversification based on a Herfindahl index. Specifically, we define the following variable:

$$Ownership\ type\ diversity = 1/\sum_i \left[ \left( \frac{Cummulative\ ownership\ of\ type\ i\ investor}{Total\ ownership\ by\ all\ investor} \right)^2 \right]$$

Note that a higher value of this measure corresponds to a more diversified ownership structure within a firm. The regression results are present in Table 5.5. Focusing on the new variable *Diversity* in column 1, we find that it has a positive and significant coefficient. This indicates that firms with a more diversified ownership structure are more likely participate in innovation activities. A similar result is obtained when we estimate a dynamic model (column 2). When we change the dependent variable from *dnp* to *nps* and use a pooled tobit estimator, we observe that the coefficient on *Diversity* is still significant and positive in columns 3 and 4. This indicates that firms with more diversified ownership structure are associated with a higher new product sales to total sales ratio. The coefficients of other variables are consistent with our earlier findings as presented in Table 5.2.

[Insert Table 5.5 here]

### 5.7.2. Instrumental variable methods

Our method of lagging the independent variables might not be sufficient to alleviate potential endogeneity. We therefore apply the instrumental variable (IV-probit and IV-tobit) method as a robustness test to examine our baseline model specification. We instrument all right-hand-side variables using their own values lagged twice. The new regression results are present in Table 5.6.[74] We observe a positive coefficient for *Statecap*, a negative coefficient for *Statecap*$^2$, but insignificant coefficient for *Foreigncap* and *Foreigncap*$^2$. We next test the impact of foreign ownership on product innovation in different specifications, the coefficients for foreign ownership are all consistent with the findings in in Table 5.3a and 5.3b, as well as the results for other control variables. In brief, the instrumental variable results provide evidence that our baseline model findings are robust to controlling for the possible endogeneity of the regressors.

[Insert Table 5.6 here]

### 5.7.3. Using an alternative measure of innovation activity

In our further robustness test, we use R&D expenditure as an alternative measure of innovation activity. Table 5.7a presents summary statistics for *drd*, *rds*, and *rda*. Specifically, *drd* is a binary variable which takes a value of one if a firm has positive R&D expenditure, and zero otherwise. *rds/rda* is a censored variable which is equal to zero if a firm does not innovate, and takes the value of the actual ratio of R&D expenditure to total sales/assets otherwise. As shown in Panel A, with the rise of state ownership, all three measures first increase and then decrease, showing an inverted U-shaped trend. Focusing on the statistics in Panel B, the values of these three measures decline as foreign ownership increases.

[Insert Table 5.7a here]

Regression results are presented in Table 5.7b, based on the pooled probit and

[74] We do not report marginal effect in this table because marginal effects are not available after IV-probit/IV-tobit two step estimators.

tobit methods. We observe a positive coefficient for *Statecap*, and a negative coefficient for *Statecap*$^2$, indicating once again an inverted U-shaped relationship between state ownership and product innovation. We also observed a positive coefficient for *DF* and *DF0100*, and a negative coefficient for *Foreigncap*, indicating that foreign-affiliated firms, especially foreign-affiliated joint-venture firms, are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases. This, once again, provides support for our Hypotheses 2 and 3.

[Insert Table 5.7b here]

## 5.8. Conclusion

Using data from 114,881 mainly unlisted Chinese firms over the period 2000−2007, we find a significant positive effect of joint ventures on innovation activity. Moreover, our results indicate an inverse U-shaped relationship between state ownership and product innovation. For foreign-affiliated firms, especially for foreign-affiliated joint-venture firms, they are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases. We also report strong evidence that, conditional on absorptive capacity, the relationship between foreign ownership and product innovation becomes positive for foreign-affiliated joint-venture firms. These results are consistent with a variety of theories and are robust to a range of estimation methods.

Our findings suggest that relevant policies should be established to promote Chinese firms' innovation activities. Specifically, joint ventures should be encouraged in order to promote innovation activities. State ownership should also be recommended but should not go beyond a certain threshold (around 70%). Chinese enterprises, on the one hand, should continue introduce foreign investors as they are generally more likely to innovate than domestic investors. On the other hand, government should encourage the form of joint venture cooperation instead of fully foreign invested pattern. The negative impact of foreign ownership on innovation may also due to uncertain innovation projects, undeveloped stock market, unhealthy financial system, unsound intellectual property rights and shareholder rights protection, and unregulated patent legal system. Therefore, external incentives should be strengthened to change these situations, and to make foreign investors more confidence when participate in innovation activities in China. At last, Chinese firms themselves should strengthen their absorptive capacity to recognize the value of new, external information or technology, learn and assimilate it from their foreign partners, then internalize and exploit it, and finally create their own innovation and apply it to commercial ends.

Further research should be undertaken in the following directions: First, as our regressions are only based on the probit/tobit model, it would be prudent to examine whether these results are robust to using other methods, such as the propensity score matching method (Girma et al., 2012). Second, future work could test whether our results also hold for listed firms. Third, one could investigate whether similar results are observed in other developing countries.

## Table 5.1: Summary statistics

*Panel A:*

| | $S = 0\%$ | $0\% < S < 50\%$ | $50\% \leq S < 100\%$ | $S = 100\%$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *dnp* | 0.087 | 0.183 | 0.206 | 0.146 |
| *nps* | 0.033 | 0.067 | 0.068 | 0.044 |
| *npa* | 0.047 | 0.058 | 0.050 | 0.031 |
| *Observations* | 509,232 | 14,057 | 11,992 | 28,105 |

*Panel B:*

| | $F = 0\%$ | $0\% < F < 50\%$ | $50\% \leq F < 100\%$ | $F = 100\%$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *dnp* | 0.100 | 0.127 | 0.101 | 0.050 |
| *nps* | 0.037 | 0.051 | 0.043 | 0.020 |
| *npa* | 0.048 | 0.060 | 0.051 | 0.027 |
| *Observations* | 418,415 | 40,878 | 27,993 | 76,100 |

*Notes:* $S$ represents the fraction of the firm's capital paid in by the state. $F$ represents the fraction of the firm's capital paid in by foreign investors. See the Appendix for complete definitions of all variables.

**Table 5.2: Are joint-ventures more likely to innovate?**

| | dnp | dnp | dnp | nps | nps | nps |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Lagged dep. Variable* | | $2.305^{***}$ | $2.300^{***}$ | | $1.557^{***}$ | $1.552^{***}$ |
| | | (0.009) | (0.009) | | (0.007) | (0.007) |
| | | [0.221] | [0.220] | | [0.257] | [0.256] |
| $JV_{i,t-1}$ | $0.114^{***}$ | $0.053^{***}$ | $0.051^{***}$ | $0.080^{***}$ | $0.031^{***}$ | $0.029^{***}$ |
| | (0.007) | (0.009) | (0.009) | (0.005) | (0.004) | (0.004) |
| | [0.018] | [0.005] | [0.005] | [0.013] | [0.005] | [0.005] |
| $Size_{i,t-1}$ | $0.230^{***}$ | $0.139^{***}$ | $0.140^{***}$ | $0.157^{***}$ | $0.077^{***}$ | $0.077^{***}$ |
| | (0.003) | (0.004) | (0.004) | (0.002) | (0.002) | (0.002) |
| | [0.037] | [0.013] | [0.013] | [0.026] | [0.013] | [0.013] |
| $Leverage_{i,t-1}$ | $0.133^{***}$ | $0.074^{***}$ | $0.071^{***}$ | $0.065^{***}$ | $0.056^{***}$ | $0.053^{***}$ |
| | (0.013) | (0.017) | (0.017) | (0.010) | (0.007) | (0.007) |
| | [0.021] | [0.007] | [0.007] | [0.011] | [0.009] | [0.009] |
| $Collateral_{i,t-1}$ | -0.024 | $-0.058^{**}$ | $-0.070^{***}$ | $-0.045^{***}$ | 0.010 | -0.001 |
| | (0.019) | (0.023) | (0.023) | (0.013) | (0.002) | (0.009) |
| | | [-0.006] | [-0.007] | [-0.007] | | |
| $Expdum_{i,t}$ | $0.321^{***}$ | $0.103^{***}$ | $0.113^{***}$ | $0.210^{***}$ | $0.110^{***}$ | $0.118^{***}$ |
| | (0.007) | (0.008) | (0.008) | (0.005) | (0.003) | (0.003) |
| | [0.051] | [0.010] | [0.011] | [0.034] | [0.018] | [0.019] |
| $Compete_{i,t}$ | | | $1.374^{***}$ | | | $1.316^{***}$ |
| | | | (0.344) | | | (0.149) |
| | | | [0.132] | | | [0.217] |
| $Compete^2_{i,t}$ | | | $-1.207^{***}$ | | | $-1.110^{***}$ |
| | | | (0.224) | | | (0.095) |
| | | | [-0.115] | | | [-0.183] |
| $Tech\_gap_{i,t}$ | | | $0.677^{***}$ | | | $0.433^{***}$ |
| | | | (0.173) | | | (0.068) |
| | | | [0.065] | | | [0.071] |
| *Pseudo $R^2$* | 0.091 | 0.442 | 0.443 | 0.085 | 0.342 | 0.344 |
| *Observations* | 340,384 | 340,384 | 340,384 | 340,384 | 340,384 | 340,384 |

*Note*: The dependent variable *dnp* is a binary variable which takes value of one if the firm has new products, and zero otherwise. The dependent variable *nps* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of new products to total sales otherwise. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively. Marginal effects are in square brackets for those variables that are statistically significant. Time dummies and industry dummies are included in estimation. See the Appendix for complete definitions of all variables. The results in column 1 to 3 are estimated by using the pooled probit estimator, and the results in column 4 to 5 are regressed based on the pooled tobit estimator.

**Table 5.3a: Relationship between state/foreign ownership and firms' innovation activity (the pooled probit model)**

| | dnp (1) | dnp (3) | dnp (2) | dnp (4) | dnp (5) | dnp (6) |
|---|---|---|---|---|---|---|
| *Lagged dep. variable* | 2.258*** | 2.255*** | 2.255*** | 2.255*** | 2.255*** | 2.255*** |
| | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) |
| | [0.206] | [0.214] | [0.214] | [0.214] | [0.214] | [0.214] |
| **Main variables:** | | | | | | |
| *$Statecap_{i,t-1}$* | 0.266*** | 0.798*** | 0.813*** | 0.805*** | 0.799*** | 0.801*** |
| | (0.020) | (0.088) | (0.087) | (0.088) | (0.088) | (0.088) |
| | [0.015] | [0.076] | [0.077] | [0.076] | [0.076] | [0.076] |
| *$Statecap^2_{i,t-1}$* | | -0.566*** | -0.582*** | -0.574*** | -0.567*** | -0.569*** |
| | | (0.091) | (0.091) | (0.092) | (0.092) | (0.092) |
| | | [-0.054] | [-0.055] | [-0.054] | [-0.054] | [-0.054] |
| *$Foreigncap_{i,t-1}$* | -0.223*** | 0.102 | -0.351*** | -0.163 | -0.267*** | -0.375** |
| | (0.018) | (0.070) | (0.030) | (0.152) | (0.048) | (0.186) |
| | [-0.021] | | [-0.033] | | [-0.025] | [-0.035] |
| *$Foreigncap^2_{i,t-1}$* | | -0.350*** | | -0.154 | | 0.109 |
| | | (0.071) | | (0.122) | | (0.182) |
| | | [-0.033] | | | | |
| *$DF_{i,t-1}$* | | | 0.113*** | 0.075** | | |
| | | | (0.022) | (0.038) | | |
| | | | [0.011] | [0.007] | | |
| *$DF0100_{i,t-1}$* | | | | | 0.088*** | 0.108*** |
| | | | | | (0.025) | (0.041) |
| | | | | | [0.008] | [0.010] |
| *$DF100_{i,t-1}$* | | | | | 0.018 | 0.017 |
| | | | | | (0.048) | (0.048) |
| **Control variables:** | | | | | | |
| *$Size_{i,t-1}$* | 0.154*** | 0.150*** | 0.150*** | 0.150*** | 0.150*** | 0.150*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| | [0.015] | [0.014] | [0.014] | [0.014] | [0.014] | [0.014] |
| *$Leverage_{i,t-1}$* | -0.047*** | -0.039** | -0.040** | -0.039** | -0.038** | -0.039** |
| | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) | (0.017) |
| | [-0.004] | [-0.004] | [-0.004] | [-0.004] | [-0.004] | [-0.004] |
| *$Collateral_{i,t-1}$* | -0.126*** | -0.109*** | -0.109*** | -0.109*** | -0.109*** | -0.109*** |
| | (0.023) | (0.024) | (0.024) | (0.024) | (0.024) | (0.024) |
| | [-0.012] | [-0.010] | [-0.010] | [-0.010] | [-0.010] | [-0.010] |
| *$Expdum_{i,t}$* | 0.196*** | 0.191*** | 0.190*** | 0.190*** | 0.190*** | 0.191*** |
| | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) |
| | [0.019] | [0.018] | [0.018] | [0.018] | [0.018] | [0.018] |
| *$Compete_{i,t}$* | 1.160*** | 1.110*** | 1.111*** | 1.111*** | 1.109*** | 1.109*** |
| | (0.341) | (0.340) | (0.340) | (0.340) | (0.340) | (0.340) |
| | [0.110] | [0.105] | [0.105] | [0.105] | [0.105] | [0.105] |
| *$Compete^2_{i,t}$* | -0.973*** | -0.933*** | -0.934*** | -0.934*** | -0.933*** | -0.933*** |
| | (0.223) | (0.222) | (0.222) | (0.222) | (0.222) | (0.222) |
| | [-0.092] | [-0.088] | [-0.088] | [-0.088] | [-0.088] | [-0.088] |
| *$Tech\_gap_{i,t}$* | 0.485*** | 0.469*** | 0.473*** | 0.472*** | 0.470*** | 0.470*** |
| | (0.173) | (0.173) | (0.173) | (0.173) | (0.173) | (0.173) |
| | [0.046] | [0.044] | [0.045] | [0.045] | [0.045] | [0.045] |
| *$Privatecap_{i,t-1}$* | 0.181*** | 0.364*** | 0.378*** | 0.356*** | 0.352*** | 0.360*** |
| | (0.015) | (0.066) | (0.064) | (0.066) | (0.065) | (0.066) |
| | [0.017] | [0.035] | [0.036] | [0.034] | [0.033] | [0.034] |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Privatecap$^2_{i,t-1}$* | | -1.180*** | -1.192*** | -1.171*** | -1.167*** | -1.175*** |
| | | (0.063) | (0.061) | (0.063) | (0.062) | (0.063) |
| | | [-0.017] | [-0.018] | [-0.016] | [-0.016] | [-0.017] |
| *Pseudo $R^2$* | 0.448 | 0.448 | 0.448 | 0.448 | 0.448 | 0.448 |
| *Observations* | 340,384 | 340,384 | 340,384 | 340,384 | 340,384 | 340,384 |

*Note*: The dependent variable *dnp* is a binary variable which takes value of one if the firm has new products, and zero otherwise. The dependent variable *nps* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of new products to total sales otherwise. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively. Marginal effects are in square brackets for those variables that are statistically significant. Time dummies and industry dummies are included in estimation. See the Appendix for complete definitions of all variables. All results are estimated by using the pooled probit estimator.

**Table 5.3b: Relationship between state/foreign ownership and firms' innovation activity (the pooled tobit model)**

| | nps | nps | nps | nps | nps | nps |
|---|---|---|---|---|---|---|
| | (1) | (3) | (2) | (4) | (5) | (5) |
| *Lagged dep. variable* | 1.519*** | 1.514*** | 1.514*** | 1.514*** | 1.514*** | 1.514*** |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) |
| | [0.249] | [0.248] | [0.248] | [0.248] | [0.248] | [0.248] |
| **Main variables:** | | | | | | |
| $Statecap_{i,t-1}$ | 0.153*** | 0.453*** | 0.442*** | 0.421*** | 0.417*** | 0.417*** |
| | (0.008) | (0.046) | (0.033) | (0.033) | (0.033) | (0.033) |
| | [0.025] | [0.074] | [0.069] | [0.069] | [0.068] | [0.068] |
| $Statecap^2_{i,t-1}$ | | -0.282*** | -0.285*** | -0.284*** | -0.279*** | -0.279*** |
| | | (0.035) | (0.035) | (0.035) | (0.035) | (0.035) |
| | | [-0.046] | [-0.047] | [-0.047] | [-0.046] | [-0.046] |
| $Foreigncap_{i,t-1}$ | -0.176*** | -0.060 | -0.214*** | -0.188*** | -0.176*** | -0.449*** |
| | (0.007) | (0.039) | (0.012) | (0.058) | (0.019) | (0.170) |
| | [-0.029] | | [-0.035] | [-0.031] | [-0.029] | [-0.073] |
| $Foreigncap^2_{i,t-1}$ | | -0.091*** | | -0.022 | | 0.446 |
| | | (0.028) | | (0.047) | | (0.384) |
| | | [-0.015] | | | | |
| $DF_{i,t-1}$ | | | 0.033*** | 0.027* | | |
| | | | (0.009) | (0.015) | | |
| | | | [0.005] | [0.004] | | |
| $DF0100_{i,t-1}$ | | | | | 0.021** | 0.062*** |
| | | | | | (0.010) | (0.023) |
| | | | | | [0.003] | [0.010] |
| $DF100_{i,t-1}$ | | | | | -0.012 | 0.011 |
| | | | | | (0.019) | (0.002) |
| **Control variables:** | | | | | | |
| $Size_{i,t-1}$ | 0.083*** | 0.081*** | 0.080*** | 0.080*** | 0.080*** | 0.080*** |
| | (0.014) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| | [0.015] | [0.013] | [0.013] | [0.013] | [0.013] | [0.013] |
| $Leverage_{i,t-1}$ | -0.026*** | -0.023*** | -0.023*** | -0.023*** | -0.022*** | -0.022*** |
| | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) | (0.007) |
| | [-0.004] | [-0.004] | [-0.004] | [-0.004] | [-0.004] | [-0.004] |
| $Collateral_{i,t-1}$ | -0.036*** | -0.029*** | -0.029*** | -0.028*** | -0.028*** | -0.029*** |
| | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) |
| | [-0.006] | [-0.005] | [-0.005] | [-0.005] | [-0.005] | [-0.005] |
| $Expdum_{i,t}$ | 0.167*** | 0.164*** | 0.164*** | 0.164*** | 0.164*** | 0.164*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| | [0.027] | [0.027] | [0.027] | [0.027] | [0.027] | [0.027] |
| $Compete_{i,t}$ | 1.042*** | 1.005*** | 1.007*** | 1.007*** | 1.006*** | 1.005*** |
| | (0.145) | (0.144) | (0.144) | (0.144) | (0.144) | (0.144) |
| | [0.171] | [0.165] | [0.165] | [0.165] | [0.165] | [0.165] |
| $Compete^2_{i,t}$ | -0.847*** | -0.819*** | -0.821*** | -0.821*** | -0.821*** | -0.820*** |
| | (0.093) | (0.093) | (0.093) | (0.093) | (0.093) | (0.093) |
| | [-0.139] | [-0.134] | [-0.134] | [-0.134] | [-0.134] | [-0.134] |
| $Tech\_gap_{i,t}$ | 0.298*** | 0.290*** | 0.291*** | 0.291*** | 0.289*** | 0.290*** |
| | (0.068) | (0.068) | (0.068) | (0.068) | (0.068) | (0.068) |
| | [0.049] | [0.047] | [0.048] | [0.048] | [0.047] | [0.047] |
| $Privatecap_{i,t-1}$ | 0.071*** | 0.261*** | 0.217*** | 0.214*** | 0.205*** | 0.218*** |
| | (0.006) | (0.048) | (0.025) | (0.026) | (0.025) | (0.026) |
| | [0.012] | [0.043] | [0.036] | [0.035] | [0.034] | [0.036] |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Privatecap²$_{i,t-1}$* | | -1.154*** | -0.144*** | -0.140*** | -1.132*** | -0.145*** |
| | | (0.026) | (0.024) | (0.025) | (0.024) | (0.025) |
| | | [-0.025] | [-0.024] | [-0.023] | [-0.022] | [-0.024] |
| *Pseudo $R^2$* | 0.356 | 0.357 | 0.357 | 0.357 | 0.357 | 0.357 |
| *Observations* | 340,384 | 340,384 | 340,384 | 340,384 | 340,384 | 340,384 |

*Note*: The dependent variable *dnp* is a binary variable which takes value of one if the firm has new products, and zero otherwise. The dependent variable *nps* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of new products to total sales otherwise. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively. Marginal effects are in square brackets for those variables that are statistically significant. Time dummies and industry dummies are included in estimation. See the Appendix for complete definitions of all variables. All results are estimated by using the pooled tobit estimator.

**Table 5.4: Relationship between foreign ownership and firms' innovation activity: the role of absorptive capacity**

| | R&D | Past experience in innovation |
|---|---|---|
| | nps | nps |
| | (2) | (4) |
| *Lagged dep. variable* | 1.369*** | 1.230*** |
| | (0.023) | (0.021) |
| | [0.269] | [0.216] |
| **Main variables:** | | |
| $Statecap_{i,t-1}$ | 0.368*** | 0.228** |
| | (0.136) | (0.098) |
| | [0.072] | [0.040] |
| $Statecap^2_{i,t-1}$ | -0.427** | -0.230* |
| | (0.200) | (0.137) |
| | [-0.084] | [-0.040] |
| $Foreigncap_{i,t-1} \times High\_AC$ | 0.213*** | 0.319*** |
| | (0.042) | (0.038) |
| | [0.042] | [0.056] |
| $Foreigncap_{i,t-1} \times Low\_AC$ | -0.185*** | -0.409*** |
| | (0.045) | (0.036) |
| | [-0.036] | [-0.072] |
| **Control variables:** | | |
| $Size_{i,t-1}$ | 0.047*** | 0.067*** |
| | (0.005) | (0.005) |
| | [0.009] | [0.012] |
| $Leverage_{i,t-1}$ | 0.007 | 0.029 |
| | (0.025) | (0.005) |
| $Collateral_{i,t-1}$ | 0.034 | -0.016 |
| | (0.036) | (0.034) |
| $Expdum_{i,t}$ | 0.156*** | 0.118*** |
| | (0.013) | (0.012) |
| | [0.031] | [0.021] |
| $Compete_{i,t}$ | 0.860 | 1.937* |
| | (0.716) | (1.221) |
| | | [0.340] |
| $Compete^2_{i,t}$ | -0.620 | -1.193* |
| | (0.441) | (0.718) |
| | | [-0.210] |
| $Tech\_gap_{i,t}$ | 0.263 | 0.632*** |
| | (0.240) | (0.236) |
| | | [0.111] |
| $Privatecap_{i,t-1}$ | 0.131** | 0.141** |
| | (0.063) | (0.056) |
| | [0.026] | [0.025] |
| $Privatecap^2_{i,t-1}$ | -0.051 | -0.116* |
| | (0.068) | (0.066) |
| | | [-0.020] |
| $H_0$: Impact of $Foreigncap_{i,t-1}$ on *dnp/nps* same across *High_AC* and *Low_AC* firm-years *(p-value)* | 0.000 | 0.000 |
| *Pseudo* $R^2$ | 0.401 | 0.481 |
| *Observations* | 16,757 | 22,145 |

*Note*: The dependent variable *dnp* is a binary variable which takes value of one if the firm has new products, and zero otherwise. The dependent variable *nps* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of new products to total sales otherwise. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively. Marginal effects are in square brackets for those variables that are statistically significant. Time dummies and industry dummies are included in estimation. See the Appendix for complete definitions of all variables. The results in column 1 and 3 are estimated by using the pooled probit estimator, and the results in column 2 and 4 are regressed based on the pooled tobit estimator.

**Table 5.5: Robustness test: Are firms with a more diversified ownership structure more likely to innovate?**

| | dnp | dnp | nps | nps |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Lagged dep. variable* | | 2.300*** | | 1.552*** |
| | | (0.009) | | (0.007) |
| | | [0.220] | | [0.256] |
| *Diversity*$_{i,t-1}$ | 0.119*** | 0.062*** | 0.085*** | 0.031*** |
| | (0.009) | (0.012) | (0.007) | (0.005) |
| | [0.019] | [0.006] | [0.014] | [0.005] |
| *Size*$_{i,t-1}$ | 0.233*** | 0.140*** | 0.158*** | 0.077*** |
| | (0.003) | (0.004) | (0.002) | (0.002) |
| | [0.037] | [0.013] | [0.026] | [0.013] |
| *Leverage*$_{i,t-1}$ | 0.125*** | 0.071*** | 0.059*** | 0.053*** |
| | (0.013) | (0.017) | (0.010) | (0.007) |
| | [0.020] | [0.007] | [0.010] | [0.009] |
| *Collateral*$_{i,t-1}$ | -0.062*** | -0.070*** | -0.070*** | -0.002 |
| | (0.019) | (0.023) | (0.013) | (0.009) |
| | [-0.010] | [-0.007] | [-0.012] | |
| *Expdum*$_{i,t}$ | 0.350*** | 0.113*** | 0.228*** | 0.119*** |
| | (0.007) | (0.008) | (0.005) | (0.003) |
| | [0.056] | [0.011] | [0.037] | [0.020] |
| *Compete*$_{i,t}$ | 4.557*** | 1.380*** | 3.123*** | 1.322*** |
| | (0.331) | (0.344) | (0.235) | (0.149) |
| | [0.728] | [0.132] | [0.512] | [0.218] |
| *Compete*$^2_{i,t}$ | -3.809*** | -1.212*** | -2.585*** | -1.115*** |
| | (0.209) | (0.224) | (0.148) | (0.095) |
| | [-0.608] | [-0.116] | [-0.424] | [-0.184] |
| *Tech_gap*$_{i,t}$ | 1.079*** | 0.680*** | 0.615*** | 0.435*** |
| | (0.138) | (0.173) | (0.099) | (0.068) |
| | [0.172] | [0.065] | [0.101] | [0.072] |
| *Pseudo* $R^2$ | 0.095 | 0.443 | 0.088 | 0.344 |
| *Observations* | 340,384 | 340,384 | 340,384 | 340,384 |

*Note*: The dependent variable *dnp* is a binary variable which takes value of one if the firm has new products, and zero otherwise. The dependent variable *nps* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of new products to total sales otherwise. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively. Marginal effects are in square brackets for those variables that are statistically significant. Time dummies and industry dummies are included in estimation. See the Appendix for complete definitions of all variables. The results in column 1 and 2 are estimated by using the pooled probit estimator, and the results in column 3 and 4 are regressed based on the pooled tobit estimator.

**Table 5.6: Robustness test: Relationship between state/foreign ownership and firms' innovation activity controlling for potential endogeneity**

| | dnp | dnp | dnp | nps | nps | nps |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Lagged dep. Variable* | 2.334*** | 2.334*** | 2.334*** | 1.517*** | 1.517*** | 1.517*** |
| | (0.013) | (0.013) | (0.013) | (0.009) | (0.009) | (0.009) |
| **Main variables:** | | | | | | |
| *$Statecap_{i,t-1}$* | 1.012*** | 1.018*** | 1.033*** | 0.592*** | 0.592*** | 0.594*** |
| | (0.220) | (0.220) | (0.221) | (0.075) | (0.075) | (0.075) |
| *$Statecap^2_{i,t-1}$* | -0.570** | -0.577** | -0.592*** | -0.373*** | -0.372*** | -0.375*** |
| | (0.229) | (0.228) | (0.230) | (0.078) | (0.078) | (0.078) |
| *$Foreigncap_{i,t-1}$* | 0.123 | -0.211*** | -0.264*** | -0.076 | -0.176*** | -0.183*** |
| | (0.150) | (0.066) | (0.102) | (0.052) | (0.023) | (0.036) |
| *$Foreigncap^2_{i,t-1}$* | -0.231 | | | -0.064 | | |
| | (0.154) | | | (0.054) | | |
| *$DF_{i,t-1}$* | | 0.109** | | | 0.036** | |
| | | (0.049) | | | (0.017) | |
| *$DF0100_{i,t-1}$* | | | 0.126** | | | 0.039** |
| | | | (0.054) | | | (0.019) |
| *$DF100_{i,t-1}$* | | | 0.166* | | | 0.043 |
| | | | (0.100) | | | (0.035) |
| **Control variables:** | | | | | | |
| *$Size_{i,t-1}$* | 0.177*** | 0.176*** | 0.176*** | 0.083*** | 0.082*** | 0.083*** |
| | (0.006) | (0.006) | (0.006) | (0.002) | (0.002) | (0.002) |
| *$Leverage_{i,t-1}$* | -0.063* | -0.064* | -0.064* | -0.035*** | -0.035*** | -0.035*** |
| | (0.037) | (0.037) | (0.037) | (0.013) | (0.013) | (0.013) |
| *$Collateral_{i,t-1}$* | -0.250*** | -0.248*** | -0.248*** | -0.094*** | -0.094*** | -0.094*** |
| | (0.052) | (0.052) | (0.052) | (0.018) | (0.018) | (0.018) |
| *$Expdum_{i,t}$* | 0.221*** | 0.220*** | 0.219*** | 0.176*** | 0.175*** | 0.175*** |
| | (0.018) | (0.018) | (0.018) | (0.006) | (0.006) | (0.006) |
| *$Compete_{i,t}$* | 3.268*** | 3.266*** | 3.266*** | 1.448*** | 1.446*** | 1.448*** |
| | (0.818) | (0.818) | (0.818) | (0.303) | (0.303) | (0.303) |
| *$Compete^2_{i,t}$* | -2.608*** | -2.606*** | -2.606*** | -1.190*** | -1.189*** | -1.190*** |
| | (0.521) | (0.521) | (0.521) | (0.191) | (0.191) | (0.191) |
| *$Tech\_gap_{i,t}$* | 1.977*** | 1.977*** | 1.978*** | 1.058*** | 1.058*** | 1.058*** |
| | (0.549) | (0.549) | (0.549) | (0.196) | (0.196) | (0.196) |
| *$Privatecap_{i,t-1}$* | 0.883*** | 0.832*** | 0.847*** | 0.384*** | 0.358*** | 0.359*** |
| | (0.180) | (0.173) | (0.176) | (0.063) | (0.061) | (0.062) |
| *$Privatecap^2_{i,t-1}$* | -0.522*** | -0.470*** | -0.485*** | -0.251*** | -0.225*** | -0.227*** |
| | (0.172) | (0.166) | (0.169) | (0.060) | (0.058) | (0.059) |
| *Wald test of exogeneity (p-value)* | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| *Observations* | 170,766 | 170,766 | 170,766 | 170,766 | 170,766 | 170,766 |

*Note*: The dependent variable *dnp* is a binary variable which takes value of one if the firm has new products, and zero otherwise. The dependent variable *nps* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of new products to total sales otherwise. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively. Time dummies and industry dummies are included in estimation. See the Appendix for complete definitions of all variables. The results in column 1 to 3 are estimated by using the IV probit estimator, and the results in column 4 to 6 are regressed based on the IV tobit estimator.

## Table 5.7a: Robustness test: Summary statistics based on R&D expenditure

*Panel A:*

| | $S$ = 0% | 0% <$S$< 50% | 50% ≤ $S$< 100% | $S$ = 100% |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *drd* | 0.1264 | 0.2746 | 0.2494 | 0.1949 |
| *rds* | 0.016 | 0.0035 | 0.0031 | 0.0027 |
| *rda* | 0.0018 | 0.0030 | 0.0026 | 0.0018 |
| *Observations* | 251,945 | 4,447 | 3,260 | 8,931 |

*Panel B:*

| | $F$ = 0% | 0% <$F$< 50% | 50% ≤ $F$< 100% | $F$ = 100% |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *drd* | 0.1337 | 0.1783 | 0.1750 | 0.0937 |
| *rds* | 0.0017 | 0.0022 | 0.0022 | 0.0010 |
| *rda* | 0.0019 | 0.0024 | 0.0024 | 0.0010 |
| *Observations* | 202,516 | 17,238 | 10,854 | 37,975 |

*Notes: S* represents the fraction of the firm's capital paid in by state investors. *F* represents the fraction of the firm's capital paid in by foreign investors. *drd* is a binary variable which takes value of one if the firm has positive R&D expenditure and zero otherwise; *rds/rda* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of R&D expenditure to total sales/assets otherwise.

**Table 5.7b: Robustness test: Relationship between state/foreign ownership and firms' innovation activity using R&D expenditure**

| | dnp | dnp | dnp | nps | nps | nps |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Lagged dep. Variable* | 1.949*** | 1.950*** | 1.949*** | 0.666*** | 0.666*** | 0.665*** |
| | (0.011) | (0.011) | (0.011) | (0.003) | (0.003) | (0.003) |
| | [0.263] | [0.263] | [0.263] | [0.118] | [0.118] | [0.118] |
| **Main variables:** | | | | | | |
| $Statecap_{i,t-1}$ | 0.896*** | 0.907*** | 0.894*** | 0.039*** | 0.040*** | 0.039*** |
| | (0.141) | (0.141) | (0.141) | (0.006) | (0.004) | (0.004) |
| | [0.105] | [0.102] | [0.101] | [0.007] | [0.007] | [0.007] |
| $Statecap^2_{i,t-1}$ | -0.492*** | -0.503*** | -0.491*** | -0.022*** | -0.022*** | -0.021*** |
| | (0.147) | (0.147) | (0.147) | (0.004) | (0.004) | (0.004) |
| | [-0.090] | [-0.088] | [-0.086] | [-0.004] | [-0.004] | [-0.004] |
| $Foreigncap_{i,t-1}$ | -0.238 | -0.112** | -0.096* | 0.004 | -0.004*** | -0.003** |
| | (0.257) | (0.045) | (0.058) | (0.004) | (0.001) | (0.001) |
| | | [-0.015] | [-0.013] | [-0.001] | [-0.001] | [-0.001] |
| $Foreigncap^2_{i,t-1}$ | 0.208 | | | 0.008** | | |
| | (0.256) | | | (0.003) | | |
| | | | | [-0.001] | | |
| $DF_{i,t-1}$ | | 0.091*** | | | 0.002** | |
| | | (0.033) | | | (0.001) | |
| | | [0.012] | | | [0.001] | |
| $DF0100_{i,t-1}$ | | | 0.065* | | | 0.001** |
| | | | (0.036) | | | (0.001) |
| | | | [0.009] | | | [0.001] |
| $DF100_{i,t-1}$ | | | -0.015 | | | -0.005*** |
| | | | (0.064) | | | (0.002) |
| | | | | | | [-0.001] |
| **Control variables:** | | | | | | |
| $Size_{i,t-1}$ | 0.218*** | 0.218*** | 0.218*** | 0.009*** | 0.009*** | 0.009*** |
| | (0.005) | (0.005) | (0.005) | (0.001) | (0.001) | (0.001) |
| | [0.029] | [0.029] | [0.029] | [0.002] | [0.002] | [0.002] |
| $Leverage_{i,t-1}$ | -0.133*** | -0.133*** | -0.133*** | -0.008*** | -0.008*** | -0.008*** |
| | (0.021) | (0.021) | (0.021) | (0.001) | (0.001) | (0.001) |
| | [-0.018] | [-0.018] | [-0.018] | [-0.001] | [-0.002] | [-0.001] |
| $Collateral_{i,t-1}$ | -0.217*** | -0.218*** | -0.217*** | -0.011*** | -0.011*** | -0.011*** |
| | (0.029) | (0.029) | (0.029) | (0.001) | (0.001) | (0.001) |
| | [-0.029] | [-0.029] | [-0.029] | [-0.002] | [-0.002] | [-0.002] |
| $Expdum_{i,t}$ | 0.111*** | 0.111*** | 0.111*** | 0.005*** | 0.005*** | 0.005*** |
| | (0.011) | (0.011) | (0.011) | (0.001) | (0.001) | (0.001) |
| | [0.015] | [0.015] | [0.015] | [0.001] | [0.001] | [0.001] |
| $Compete_{i,t}$ | 1.753*** | 1.756*** | 1.752*** | 0.088*** | 0.088*** | 0.087*** |
| | (0.400) | (0.400) | (0.400) | (0.012) | (0.012) | (0.012) |
| | [0.236] | [0.237] | [0.236] | [0.016] | [0.016] | [0.016] |
| $Compete^2_{i,t}$ | -1.469*** | -1.471*** | -1.468*** | -0.072*** | -0.072*** | -0.072*** |
| | (0.264) | (0.264) | (0.264) | (0.008) | (0.008) | (0.008) |
| | [-0.198] | [-0.198] | [-0.198] | [-0.013] | [-0.013] | [-0.013] |
| $Tech\_gap_{i,t}$ | -0.379* | -0.377* | -0.380* | -0.039*** | -0.039*** | -0.039*** |
| | (0.200) | (0.200) | (0.200) | (0.006) | (0.006) | (0.006) |
| | [-0.051] | [-0.051] | [-0.051] | [-0.007] | [-0.007] | [-0.007] |
| $Privatecap_{i,t-1}$ | 0.612*** | 0.647*** | 0.588*** | 0.029*** | 0.032*** | 0.028*** |
| | (0.106) | (0.099) | (0.102) | (0.006) | (0.003) | (0.003) |
| | [0.083] | [0.086] | [0.079] | [0.005] | [0.006] | [0.005] |

| | | | | | | |
|---|---|---|---|---|---|---|
| *$Privatecap^2_{i,t-1}$* | -0.354*** | -0.382*** | -0.332*** | -0.018*** | -0.020*** | -0.017*** |
| | (0.101) | (0.093) | (0.097) | (0.003) | (0.003) | (0.003) |
| | [-0.048] | [-0.051] | [-0.045] | [-0.003] | [-0.004] | [-0.003] |
| *Pseudo $R^2$* | 0.384 | 0.384 | 0.384 | 0.288 | 0.288 | 0.288 |
| *Observations* | 162,125 | 162,125 | 162,125 | 162,125 | 162,125 | 162,125 |

*Note*: The dependent variable *drd* is a binary variable which takes value of one if the firm has positive R&D expenditure, and zero otherwise. The dependent variable *rds* is a censored variable which is equal to zero if the firm does not innovate, and takes the value of the actual ratio of R&D expenditure to total sales otherwise. Heteroskedasticity-consistent standard errors are reported in parentheses. ***, ** and * indicate significance at 1, 5 and 10 percent level respectively. Time dummies and industry dummies are included in estimation. See Appendix for complete definitions of all variables. The results in column 1 to 3 are estimated by using the pooled probit estimator, and the results in column 4 to 6 are regressed based on the pooled tobit estimator.

# Appendix

**Table 5.A1: Structure of our unbalanced panel**

Panel I.

| Year | ***Number of observations*** | ***Percent*** | ***Cumulative*** |
|---|---|---|---|
| *2000* | 49,222 | 8.74 | 8.74 |
| *2001* | 66,133 | 11.74 | 20.48 |
| *2002* | 80,378 | 14.27 | 34.74 |
| *2003* | 98,468 | 17.48 | 52.22 |
| *2005* | 95,184 | 16.89 | 69.12 |
| *2006* | 90,019 | 15.98 | 85.09 |
| *2007* | 83,982 | 14.91 | 100.00 |
| ***Total*** | 563,386 | 100.00 | |

Panel II.

| Number of obs. per firm | ***Number of observations*** | ***Percent*** | ***Cumulative*** |
|---|---|---|---|
| *1* | 3,482 | 0.62 | 0.62 |
| *2* | 10,146 | 1.80 | 2.42 |
| *3* | 31,197 | 5.54 | 7.96 |
| *4* | 118,000 | 20.94 | 28.90 |
| *5* | 109,125 | 19.37 | 48.27 |
| *6* | 124,668 | 22.13 | 70.40 |
| *7* | 166,768 | 29.60 | 100.00 |
| ***Total*** | 563,386 | 100.00 | |

**Definition of the variables used**

*JV (Joint-ventures)*: dummy variable equal to 1 if the firm is owned by two or more agents, and 0 otherwise.

*Statecap*: share of the firm's capital paid in by the state.

*Foreigncap*: share of the firm's capital paid in by foreign investors (including investors from Hong Kong, Macao, and Taiwan).

*Privatecap*: share of the firm's capital paid in by private investors.

*Dnp*: dummy variable equal to 1 if the firm reports a positive value of new product sales, and 0 otherwise.

*Nps*: ratio of new product sales to total sales.

*Npa*: ratio of new product sales to total assets.

*TFP*: total factor productivity calculated using the Levinsohn and Petrin (2003) method, applied separately to different industrial groups.

*Size*: natural logarithm of total real sales.

*Leverage*: ratio of current liabilities plus non-current liabilities to total assets, where current liabilities include loans, accounts payable, and other current liabilities; and non-current liabilities include long-term debt and other non-current liabilities.

*Collateral:* ratio of tangible fixed assets to total assets.

*Expdum*: dummy variable equal to 1 if the firm reports a positive value of overseas sales, and 0 otherwise.

*Total assets*: sum of the firm's fixed and current assets, where fixed assets include tangible fixed assets, intangible fixed assets, and other fixed assets; and current assets include inventories, accounts receivable, and other current assets.

*Deflators*: all variables (except tangible fixed assets) are deflated using provincial ex-factory producer price indices taken from various issues of the China Statistical Yearbook. Tangible fixed assets are deflated using a deflator for fixed capital formation.

# Chapter 6

# Conclusion

## 6.1. Summary of the findings

This thesis, using the data from NBS (National Bureau of Statistics of China) over the period 2000−2007, investigates the innovation activities in Chinese enterprises. Specifically, this research examines the effects of financial constraints, herding behavior, and various ownerships on firms' innovation activities form both macroeconomics and microeconomics perspectives. In this section, the author summarises the main findings of this thesis and discusses the implications of the findings.

The first empirical chapter, Chapter 3, tests the impact of financial constraints on Chinese firms' innovation activities. We use a very large firm-level dataset over the period 2000−2007, which consists of 120,753 unlisted firms from 31 provinces or province-equivalent municipal cities. Based on a wide range of specification and estimation methods, we document that Chinese firms' innovation activities are subject to financial constraints. Private firms suffer the most, followed by foreign firms, while SOEs and collective firms are the least financially constrained.

Moreover, the availability of internal finance represents a binding constraint for small firms, coastal firms, and firms who have low political affiliation and fewer state shares. Last, joint-ventures are less likely to face financial constraints than sole proprietorships.

In Chapter 4, making use of a panel of 19,722 Chinese innovative firms over the period 2000−2007, we explore the extent to which herding affects corporate innovation activities and investigate the impact of herding on firms' productivity. We find strong evidence in favor of herding, which is more likely to affect private, small firms, with no political affiliation. We also find a negative impact of innovation herding on firm productivity.

Chapter 5 uses data from 114,881 mainly unlisted Chinese firms over the period 2000−2007, and find a significant positive effect of joint ventures on innovation activity. Moreover, our results indicate an inverse U-shaped relationship between state ownership and product innovation. For foreign-affiliated firms, especially for foreign-affiliated joint-venture firms, they are more likely to innovate than domestic firms, but their innovation propensity and intensity both diminish as foreign ownership increases. We also report strong evidence that, conditional on absorptive capacity, the relationship between foreign ownership and product innovation becomes positive for foreign-affiliated joint-venture firms. These results are consistent with a variety of theories and are robust to a range of estimation methods.

## 6.2. Implications of the study

The findings in Chapter 3 confirm the presence of "lending bias" and "political pecking order" in the Chinese capital market. Despite being the most active innovation participant over the period examined, private firms have been discriminated against by the Chinese capital market. As for foreign firms, their innovation activities have also been constrained by the imperfection and underdevelopment of the Chinese capital. By contrast, thanks to the support these firms get from state banks and local governments, SOEs and collective firms' innovation activities are not constrained by the availability of internal finance. Our research complements "The National Medium- and Long-Term Program of Science and Technology Development (2006-2020)". Specifically, our findings suggest that policies should be established to alleviate financing obstacles to support the development of innovation activities in small private firms, coastal firms, and firms with low political affiliation, fewer state shares, and sole proprietorship. To this end, non-banking financial institutions, such as securities, insurance, trust and finance companies, could be set up.

Our findings in Chapter 4 suggest that relevant policies should be established to reduce herding behavior in Chinese firms' innovation activities, especially for private, small firms, with no political affiliation. To this end, the Chinese government should endeavour to establish a sound protection of property rights, and a strong regulated patent legal system. At the same time, information disclosure and information exchange should be encouraged to reduce asymmetric information. Finally, Chinese firms should enhance shareholders' protection and further improve corporate governance to reduce principal-agent problems.

The findings in Chapter 5 suggest that relevant policies should be established to promote Chinese firms' innovation activities. Specifically, joint ventures should be encouraged in order to promote innovation activities. State ownership should also be recommended but should not go beyond a certain threshold (around 70%). Chinese enterprises, on the one hand, should continue introduce foreign investors as they are generally more likely to innovate than domestic investors. On the other hand, government should encourage the form of joint venture cooperation instead of fully foreign invested pattern. The negative impact of foreign ownership on innovation may also due to uncertain innovation projects, undeveloped stock market, unhealthy financial system, unsound intellectual property rights and shareholder rights protection, and unregulated patent legal system. Therefore, external incentives should be strengthened to change these situations, and to make foreign investors more confidence when participate in innovation activities in China. At last, Chinese firms themselves should strengthen their absorptive capacity to recognize the value of new, external information or technology, learn and assimilate it from their foreign partners, then internalize and exploit it, and finally create their own innovation and apply it to commercial ends.

Overall, we find the significant impact of financial constraints, herding behavior, and various ownerships on Chinese firms' innovation activities or productivity, and find how these results are different under different firms' characteristics and different situations. These findings contribute to the understanding of firms' corporate finance, behavior finance, corporate governance and the importance of firm heterogeneity in firms' innovation activities, and help the government to complement the existing policy and establish new policy and finally promote innovation in China.

## 6.3. Limitations of the study

Last but not least, a few limitations of the thesis and further research need to be addressed. Specifically, in Chapter 3, as our regressions are only based on the Euler equation model, it would be interesting to test whether the results are robust to using other models, such as the error-correction model (Bond et al., 2003; Guariglia, 2008). In Chapter 4, as our regressions are only based on production innovation, it would be interesting to test whether they are robust to using other innovation measures, such as R&D investment. And it would be interesting to test the extent to which Chinese firms herd following industry leaders instead of herding following the industry average. In Chapter 5, as our regressions are only based on the probit/tobit model, it would be prudent to examine whether these results are robust to using other methods, such as the propensity score matching method (Girma et al., 2012).

## 6.4. Recommendations for future research

Future work could test whether our results also hold for listed firms, as listed firms can obtain external fund using stock in the market, which is an important channel of financing. In October 2009, the Shenzhen Stock Exchange (SZSE) launched the growth enterprise board (GEB), like a NASDAQ board, which is separate from the main board with the aim to help innovative and fast-growing firms to raise capital more easily from the market. It is interesting to examine whether the effect of financing constraints have decreased after the announcement of GEB. In addition, one could investigate whether similar results are observed in other developing countries. Moreover, it is interesting to examine whether the nature experiment of

“The Medium- and Long-term Strategic Plan for the Development of Science and Technology (2006−2020)” introduces an exogenous shock to innovation activities.

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